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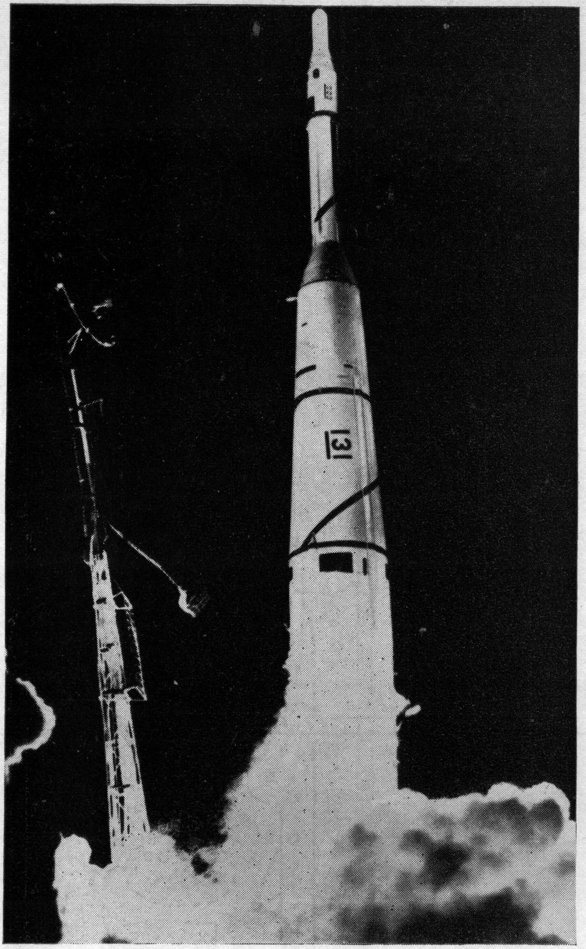

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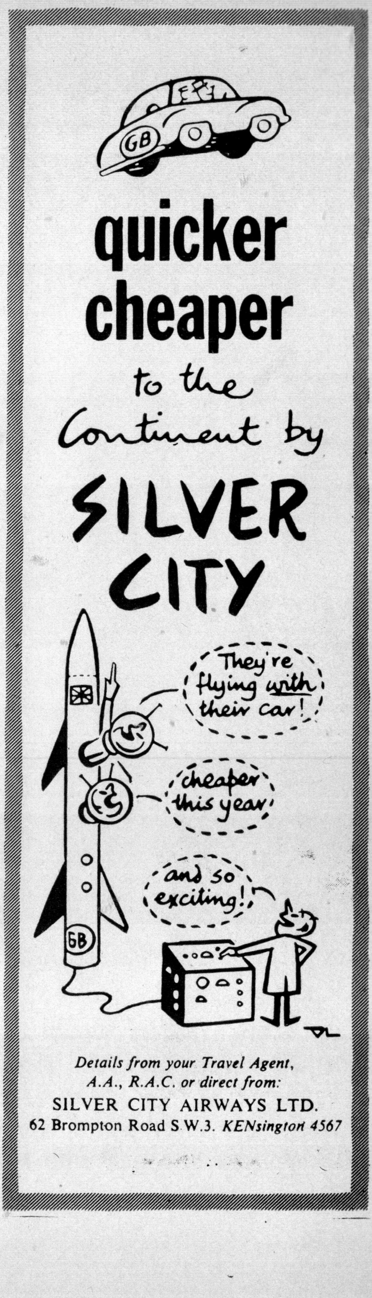
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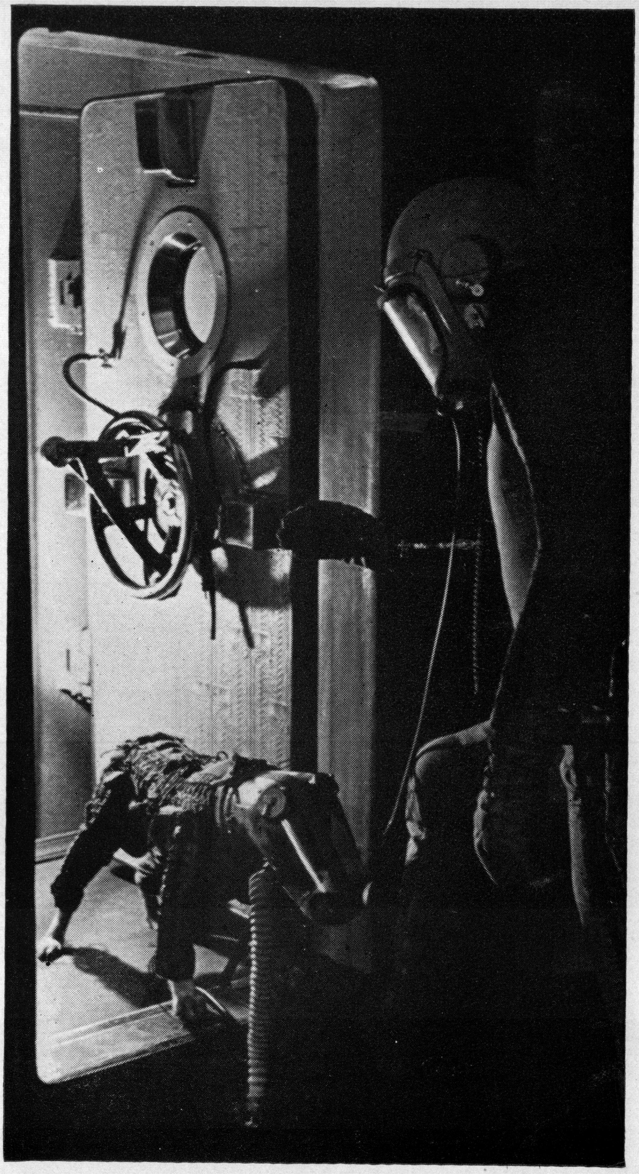

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AUTHORS' NOTE

This *ABC* would not have been possible without the enthusiastic help of many people. Our thanks go particularly to the personnel of the Royal Aircraft Establishment, *Soviet News*, the U.S. Department of Defense and the National Aeronautics and Space Administration, who provided hundreds of photographs and tens of thousands of words of data to form a sound basis for our book.

The figures quoted in the satellite data tables have been cross-checked wherever possible. In cases where differing figures were received from two or more highly authoritative sources, the data issued by the Royal Aircraft Establishment have usually been included.

M.A.

J.W.R.T.

Коммунистическая партия Советского Союза

ПРАВДА

Орган Центрального Комитета
Коммунистической партии Советского Союза

FIRST ARTIFICIAL EARTH SATELLITE

LAUNCHED IN SOVIET UNION

THE EARTH'S FIRST artificial satellite has been made as a result of intensive and large-scale work by research institutes and designing organisations. On October 4, 1957, the first satellite was successfully launched in the U.S.S.R. According to preliminary information, the carrier rocket gave the satellite the required orbital velocity of some 8,000 metres per second (17,897 m.p.h.). At the present moment the satellite is tracing an elliptical trajectory around the Earth and its flight can be observed in the rays of the rising and setting sun through the simplest optical instruments (binoculars, small telescopes, etc.).

According to calculations which are now being checked by direct observation, the satellite will move at altitudes of up to 900 kilometres (560 miles) above the Earth; the satellite will take one hour 35 minutes to make one complete revolution, and the angle at which its orbit is inclined to the equatorial plane is 65°. On October 5, the satellite will twice pass over the Moscow area—at 1.46 a.m. and 6.42 a.m. (Moscow Time). Reports on the subsequent movement of the first artificial satellite, launched in the U.S.S.R. on October 4, will be broadcast regularly by Soviet radio stations.

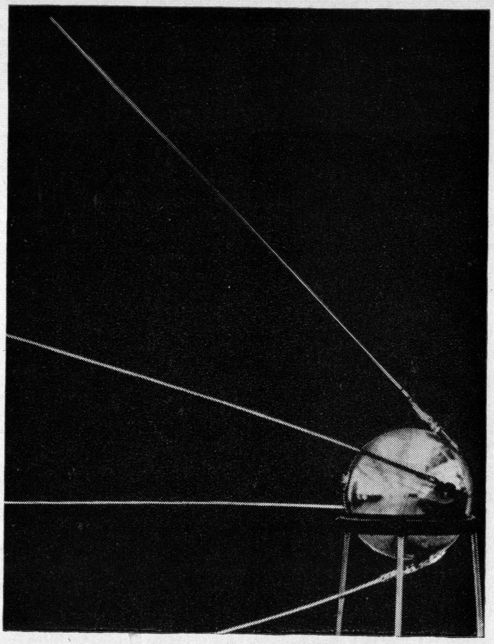
The satellite is in the form of a sphere with a diameter of 58 centimetres (23 in.) and weighs 83.6 kilograms (184 lb.). It carries two radio transmitters continuously sending signals with frequencies of 20.005 and 40.002 megacycles (the corresponding wavelengths being about 15 and 7.5 metres). The transmitters are powerful enough to ensure good reception of the radio signals by large numbers of amateur radio enthusiasts. The telegraphic signals from each set last about 0.3 seconds with pauses of the same duration. The signals on one frequency are sent during the pauses in the transmission on the other frequency.

Scientific stations in various parts of the Soviet Union are carrying out observations of the satellite and have determined the elements of its trajectory. Since there is no exact information about the density of the rarefied upper layers of the atmosphere, no data are at present available for determining how long the satellite will continue to exist and where it will enter the denser layers of the atmosphere. Calculations have shown that because of its tremendous velocity, at the end of its life the satellite will burn out on reaching the denser layers of the atmosphere at a height of some dozens of kilometres.

The possibility of space flight by means of rockets was first scientifically established in Russia as early as the end of the 19th century in the works of the outstanding Russian scientist Konstantin Tsiolkovsky.

The successful launching of the first man-made Earth satellite makes a tremendous contribution to the treasury of world science and culture. A scientific experiment performed at such a great height is of immense importance for fathoming the properties of cosmic space and for studying the Earth as a planetary member of our solar system.

Sputnik 1. *This is the first photograph issued by Russia of the world's first artificial satellite, which weighed* 184 *lb.*



THE SPACE AGE ARRIVES

REPRODUCED on the opposite page is the historic *Tass* announcement of the launching of the world's first artificial satellite. Behind its calm and factual statements lay one of the most exciting stories of all time, for the launching of *Sputnik 1* was more than just a great scientific achievement. It was the first real step towards interplanetary flight.

Tsiolkovsky's historic paper on the subject of rocket motion in 1903, Goddard's liquid-fuel rocket of 1926, the German V-2 and the U.S. Aerobee and Viking research rockets had all, in turn, been hailed as the " first step " towards space travel. But the *Sputnik* (meaning " fellow traveller ") really deserved that description.

For several years before it entered its orbit around the Earth, articles on artificial satellites and space travel had been appearing in the press at an ever-increasing rate. And, as the pattern of development slowly evolved, it had become clear that the first step on the technological ladder to the planets would, indeed, be the construction of a man-made satellite.

Dr. L. R. Shepherd, Chairman (then Technical Director) of the British Interplanetary Society, summed up the position in a paper entitled *The Artificial Satellite* which he read at the Second International Congress of Astronautics held in London in 1951. He stated: " The uses to which a satellite vehicle might be put are sufficiently numerous to justify considerable expenditure on their development. Their value as scientific research stations would be beyond measure." He continued: " *But the real value of the orbital vehicle lies in its importance as an essential springboard in the supreme adventure of interplanetary* *flight. This without doubt must be regarded as the main reason for our interest in the device, all other purposes being of secondary importance.*"

At this Congress it was revealed that one government had already decided to develop a satellite vehicle. This was confirmed in July 1955, when it was announced in Washington that the United States intended to establish small, unmanned artificial satellites in space as a contribution to the 1958-59 International Geophysical Year.

From then onward it was reasonable to assume that the orbiting of a satellite was only a matter of time; but the historic announcement from Moscow on October 5, 1957, surprised nearly everybody.

The reason was not so much that a satellite had been launched, but that it had gone up from Russia, over Moscow, instead of south-east from Florida, over the Atlantic! Yet this ought not to have been a surprise. Professor Leonid Sedov had announced at the sixth International Congress of Astronautics, in Copenhagen in 1955, that the Soviet Union intended to launch satellites during the Geophysical Year. There was a reminder in the *Soviet Weekly* as late as September 19, 1957, that " Preparations for an intensive programme of observations of the artificial satellites to be launched in the near future are under way. . . ." Unfortunately such statements were overshadowed completely by the tremendous publicity campaign for the American satellite programme, code-named Project Vanguard.

After the bare facts of the announcement had been taken in, the press was scanned eagerly for further details. The figures quoted for the *Sputnik's* weight varied slightly according to the source, but they averaged around 180 lb.—a figure which caused almost as much surprise as the satellite itself. Many people, including rocket experts, were convinced that a decimal point had slipped somewhere; but it soon became clear that the satellite did, in fact, weigh 184 lb.

This was very much heavier than most western scientists had thought practicable for the important first step towards interplanetary flight. Most studies at the time had, on the grounds of economy, been concerned with the smallest, and cheapest possible, worthwhile orbital vehicle. For example, the American Vanguard was designed expressly to the minimum size that could reasonably be expected to establish an instrumented satellite in orbit, and its powerplant developed only half the thrust of the wartime V-2.

The next big surprise concerned the Sputnik's orbit, since little or no assistance had been obtained from the rotation of the Earth. In the case of launches along the line of the equator this " free " boost can be worth about 900 m.p.h., and it had often been suggested that the first satellites would be launched on, or near, the equator to take advantage of this. The Russian achievement provided a good example of how scientific progress does not always follow the expected path. It further indicated that the Russians must have had available a launching vehicle of impressive power.

World Reaction

As many readers will remember, the launching of *Sputnik 1* filled the newspaper headlines of the world. Comments—learned, humorous, uninformed and enthusiastic—were plentiful.

The most stupid remark was that made by Rear Admiral Rawson Bennett' U.S. Chief of Naval Research, who stated on October 6: " the satellite is a hunk of iron almost anybody could launch ". A near second was that of an American " expert " who suggested that the orbit " had been deliberately arranged to prevent observation in western countries ". Dr. John Hagen, Director of the

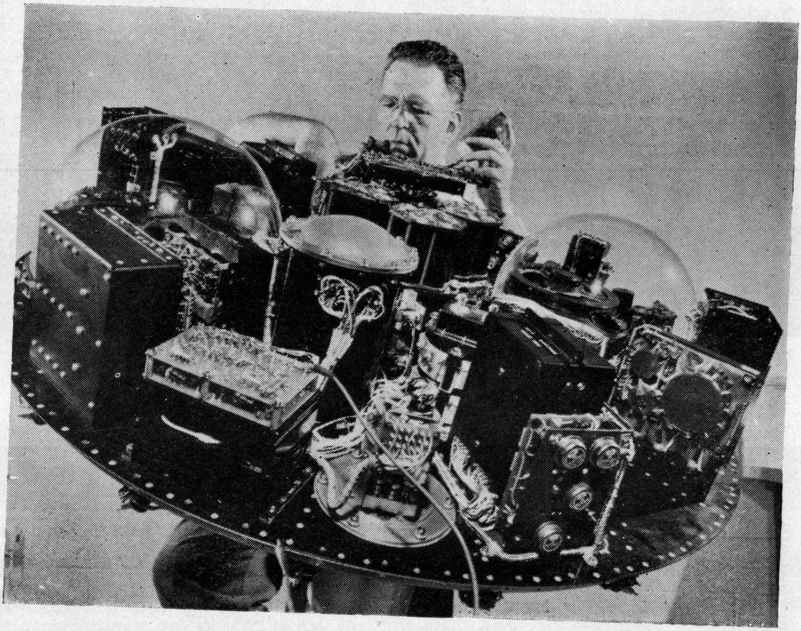
American Vanguard project, is said to have accused Russia of "unethical conduct" in putting up the *Sputnik* when she did.

As might be expected, the ugly idea of missile-launching manned satellites appeared in numerous papers. One, summing up the comments of "experts", stated "The space station could be the greatest force for peace ever devised or one of the most terrible weapons of war—depending on who builds and controls it. A ruthless power established on a space station could subjugate the peoples of the world. Sweeping round the Earth, this man-made island in the heavens could be used as a platform from which to launch guided missiles.

"Radar-controlled projectiles armed with atomic warheads could be fired at any target on the Earth's surface with devastating accuracy, and because of their enormous speeds and relatively small size, it would be impossible to intercept such missiles."

Why it should be considered better to shoot an H-rocket into an orbit, catch it, take it inside a space station, and then fire it back to Earth, when it would be so much easier to fire it from its launching site on Earth direct to the target, is never explained. The technical difficulties of getting rocket-propelled H-bombs into an orbit are enormous. After that, launching a missile from a station will not entail merely waiting until the target is directly below and then letting it go; the orbital speed of the missile will have to be lost, entailing the expenditure of almost as much energy as was required in gaining it!

The electronic complexity of the U.S. weather reconnaissance satellite Tiros 1, of 1960, *demonstrates graphically the rapid advances made in the new science of astronautics since Sputnik 1 was launched in* 1957.



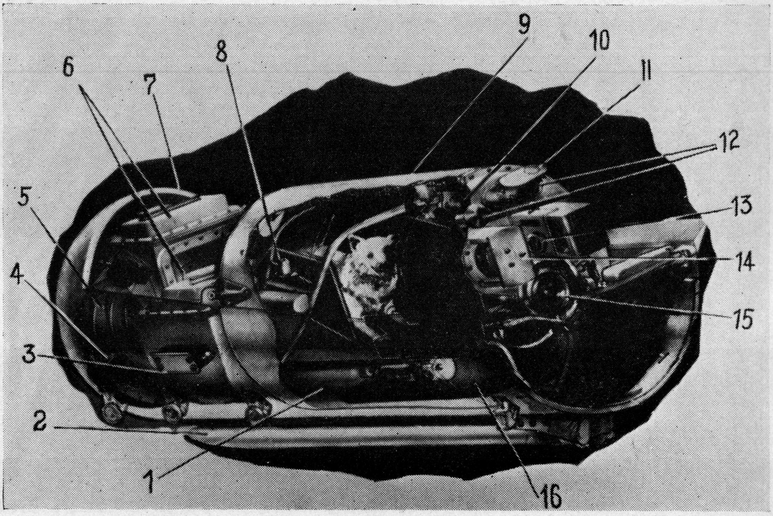
Dr. Wooley, who went on record at the time of his appointment as Astronomer Royal for describing space travel as " utter bilge ", hedged in answer to queries about the *Sputnik* in orbit overhead by saying " It depends on what you mean by utter bilge ". However, he did voice the opinion that it was a " frightful waste of public money ", which seemed to go some way towards disposing of Judge Washburn's old dictum that " it is impossible always to be wrong ".

The observatory of which Dr. Wooley is in charge—Hurstmonceux—also achieved immortality in its own way. The *Sputnik* was a tremendous scientific event and, not unnaturally, enquiries for information were addressed to Hurstmonceux. Unfortunately, the Russians had been inconsiderate enough to launch their satellite on a Friday evening, and this is the time when Hurstmonceux closes down for the weekend. Press statements indicate that about the only information given to journalists during that historic weekend was to the effect that the staff of the Observatory worked a five-day week!

In Britain, there were a number of people who seemed to derive enjoyment from the disappointment of the Americans, particularly those who were engaged upon Vanguard, at having been beaten by Russia. To such people one newspaper pointed out that the United States was at least in the " race ". While other countries lifted up their eyes to the stars, Britain's feet were firmly in the sand.

At the time of going to press, they were still there.

The pressurised animal cabin of **Sputnik 5**, *showing (1) air supply tank; (2) ejection firing device; (3) radio unit; (4) heating battery; (5) storage battery; (6) instrumentation; (7) ejection mechanism; (8) movement transducer; (9) pressurised animal capsule; (10) microphone; (11) radio aerial; (12) intake and exhaust valves; (13) TV camera; (14) mirror; (15) ventilator; (16) automatic feeder.*



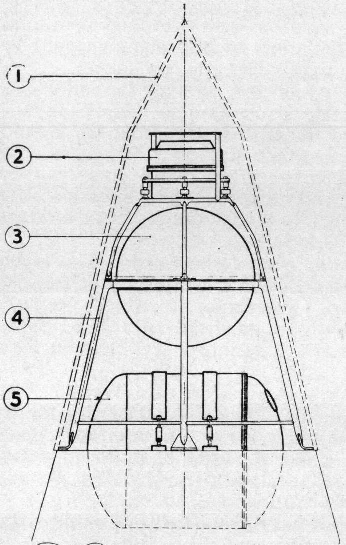
SATELLITE SURVEY

WEAVING its cats-cradle orbit over our heads in the Autumn of 1957, *Sputnik* 1 left many questions unanswered. Was it a lucky first shot for the Russians? Did its weight indicate that they had used as a booster an intercontinental ballistic missile (ICBM) of sufficient power to deliver an H-bomb on America? Did the very satisfactory orbit indicate that the Russians had developed precise guidance systems that would enable such an ICBM to hit pinpoint targets? Did the *Sputnik* contain instruments of sufficient quality to send back worthwhile scientific data? Above all, could the Russians do it again?

The last question was answered within a month, in a way that made it possible to deduce answers to most of the others.

Sputnik 2, launched on November 3, 1957, was not simply a carbon copy of its predecessor. On the contrary, it comprised a huge cone-shaped body, 7 ft. long, with a diameter of 3 ft. 6 in. and an astounding weight of half-a-ton. Here was an answer to the question of whether Russian rockets had the power to reach America. Furthermore, as the orbit was again inclined at a precise 65° to the equator it was clear that Soviet guidance systems were of the highest calibre. But the biggest surprise of all was that the " scientific " payload included a husky-type dog named *Laika*, which thus became the first real traveller in space.

Tiny monkeys, mice and other living things had made brief journeys above the effective atmosphere in rockets before this; but their up-and-down sorties were very different from the adventure on which *Laika* had embarked. For day after day following the launching, research workers in Russia were able to interpret information radioed back by the satellite to discover the effects on a



Left: *diagram of* **Sputnik 2,** *showing* (1) *nose cone*, (2) *radiation instruments*, (3) *radio transmitter capsule*, (4) *frame securing instruments*, *and* (5) *sealed chamber for the test animal*. Below: *Space dog* **Laika.**

living body of prolonged " weightlessness ", cosmic radiation and other features of orbital flight. They were encouraged by the apparent absence of ill-effects as *Laika* journeyed on in her little air-conditioned cabin, supplied with food, water and other essentials.

News of this further great advance in scientific achievement met with a mixed reception in Britain. Uppermost in many minds was the question of what would happen to *Laika* when her supply of air and food ran out. Had the Russians solved the tremendous problem of getting a satellite back into the atmosphere without its being burned up by frictional heat, like a shooting star? The answer came in a Moscow broadcast statement that, after eight days, *Laika* would die painlessly.

There were immediate protests from many parts of the world, to which the Russians replied, with entire justification, that they too love animals, but that sacrifices are inevitable in so great an undertaking as interplanetary flight.

On the day before *Laika* died, the radio of *Sputnik* 2 ceased transmitting, but the conical satellite continued on its silent way for another five months. In the second week of April 1958, people in England were able to watch it with the naked eye for a while, crossing the sky like a brightly-shining, fast-moving star shortly after sunset. Then, on April 14, it failed to appear and we knew it had ended its life as a fiery streak of white-hot metal in the upper atmosphere.

Sputnik 1 had met the same fate three months earlier, but the Earth was not without a man-made Moon. Nor would it ever again be without one, for the " space race " was on in earnest.

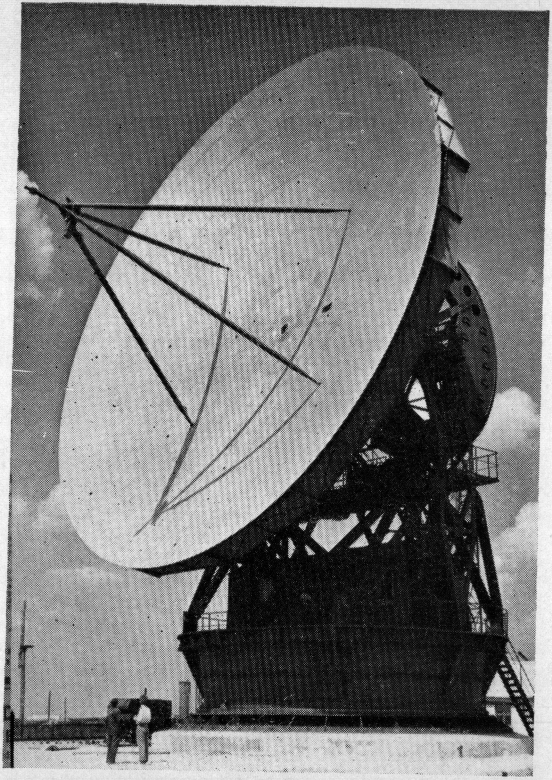
Vanguard was meeting with little success. Determined that their first step into space should be purely scientific and divorced from military projects, U.S. scientists had not, like the Russians, adapted a war missile as the booster for Vanguard. Instead, they had designed from scratch a three-stage rocket tailored perfectly for the job of launching into orbit a 20 in. spherical satellite weighing about 21 lb. The small size of the satellite was to be offset by miniaturisation of its payload, so that an immense variety of information would be obtained from instruments and radio packed tightly into the tiny sphere.

Looking back now, it is easy to accuse the Americans of being too ambitious and to laud the Russians for their more realistic decision to adapt standard military rockets and avoid too-sophisticated miniaturisation. But we should remember that the Americans stated from the start of Project Vanguard that they could hope to get into orbit no more than five of the dozen satellites they planned to launch. Too many of the folk who accepted this proportion as a potentially great achievement in 1955 were quick to pour scorn on the Americans when the first few Vanguard launchings ended in failure.

At the end of 1957, only the two *Sputniks* circled the Earth. The latest Vanguard launching, Test Vehicle No. 3, had ended in a spectacular ball of fire only two seconds after take-off on December 6. Fearful for his nation's prestige, President Eisenhower had, meanwhile, given the go-ahead to a U.S. Army project to adapt the well proven Redstone war rocket into a satellite launching vehicle.

Leader of the Army missile team at Redstone Arsenal was Dr. Wernher von Braun, designer of the V-2 rockets with which Germany attacked London in World War II. Now an American citizen, he and many of his former colleagues from Peenemunde Research Station had given America a much improved development of the V-2. This was Redstone, and from it they were already evolving a far more formidable ballistic missile known as Jupiter.

To test Jupiter components, Redstones were being modified into multi-stage research vehicles under the designation Jupiter-C, and it was Jupiter-C which formed the basis of the Army's projected satellite vehicle.



Soviet steerable radio telescope, designed and built by scientists of the Lebeder Institute of Physics, is linked with an automatic optical telescope for visual tracking.

On January 31, 1958, all America seemed to hold its breath as the final preparations were made to launch a Jupiter-C, carrying as its fourth stage a pencil-shaped satellite known as Explorer 1. Anxiety changed to relief and jubilation when the satellite was known to be in orbit. There were more disappointments to come; but the United States had finally stepped out into space.

More important was that, having satisfied the politicians and the people at large by orbiting something, U.S. technicians were able to concentrate on the main task of ensuring that their efforts produced worthwhile scientific results.

It was soon clear that space held hazards which had not been made apparent by *Laika's* eight-day journey. As we shall see in the next chapter, Explorer 1 gave a first hint of a hitherto unsuspected belt of radiation, 600 miles above the Earth, so intense that a space-man subjected to its bombardment on an interplanetary voyage might die. Further Explorer satellites were built and equipped to confirm the existence of the radiation belt.

At last Project Vanguard, too, achieved a modest initial success. On March 17, 1958, it put into orbit a spherical payload so small that it was nicknamed the " grapefruit satellite ". Despite its small size, this little " moon " was by no means a toy. It has continued to send back data ever since and may still

Replicas of the emblems carried by **Lunik 2.**

be orbiting the Earth 2,000 years from now, long after its larger companions have met a fiery end.

The reason for Vanguard 1's great life expectancy is that its orbit is higher than that of other satellites (see page 29 for an explanation of this). Another fact about orbits, worth noting at this stage, concerns their inclination.

As we have seen, *Sputniks* 1 and 2 entered orbits inclined at 65° to the equator. The importance of this particular inclination is that it took them in time over all land areas lying approximately between the Arctic and Antarctic Circles.

The reason is that the Earth rotates on its axis while the satellites are speeding round it. As a result, if *Sputnik* 1 passed over London on one revolution, the following orbit took it over a point some 1,000 miles west of London, the next a point 2,000 miles west of London, and so on.

Explorer 1, inclined at 33° to the equator, passed over a much smaller area of the Earth's surface (i.e. that area between latitudes 33°N. and 33°S). For many types of experiment this is quite adequate. Right from the start, however, it was clear that the ideal path for a satellite would be a polar orbit, passing over the North and South Poles; because such an orbit would in time cross every square mile of Earth's surface.

Consequently, as soon as America began to build more powerful launching vehicles, like the Thor-Agena, her scientists planned to try to put their satellites into a polar orbit. There is some doubt whether Discoverer 1, launched on February 28, 1959, achieved this; but Discoverer 2 certainly did, and several U.S. satellites have since entered 80° orbits, which are nearly as good. By comparison, Russia has stuck rigidly, and with great precision, to the 65° inclination first used for *Sputnik* 1.

When we recall the tremendous excitement caused by the launching of the first *Sputniks,* it seems incredible that, three years later, satellite launchings should be taken so much for granted that they earn no more than a tiny paragraph in the newspapers. In fact, not one person in a hundred has any idea of the total number that have achieved orbit successfully.

The score in August 1960 was five *Sputniks* and 24 U.S. satellites, of which *Sputnik* 4 and 12 of the U.S. satellites were still in space. Some of them have been quite remarkable.

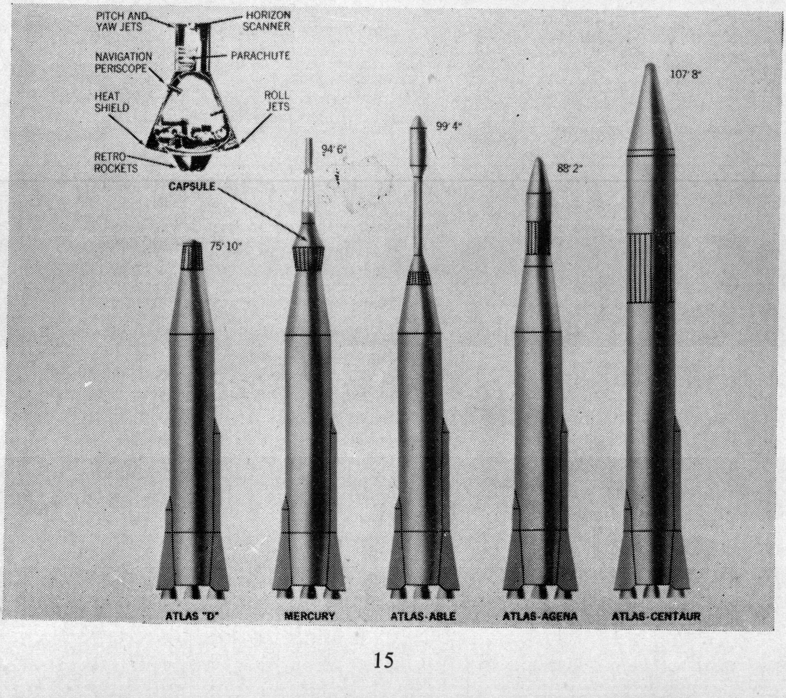
An early variation from the conventional data-gathering type of satellite was the complete Atlas ICBM put into orbit from Cape Canaveral, Florida, on December 18, 1958, under Project Score. Quite apart from its great size and weight, it made headlines by transmitting to Earth a recorded Christmas message from President Eisenhower—a gesture that was easier to appreciate if one forgot that the normal payload of an Atlas is an H-bomb warhead and that the first major use of the communications satellites that will follow the Score Atlas will be for military purposes.

However, we must not be too cynical. Except for the Vanguard satellites, almost all those orbited to date were launched by modified military missiles, the development costs of which were written off as defence expenditure. But for this, progress in space would have been far less rapid.

One day, communications satellites will be used commercially. America has also shown how weather forecasting might be made an exact science by the use of TV satellites like Tiros; and how navigation might be made easier and more accurate through the assistance of automatic navigation satellites like Transit.

At the moment, much of the data transmitted by the latest satellites is secret, because of its potential military value; but there is little doubt that America has caught up in this respect and has learned a vast amount from its highly-instrumented satellites. Russia, on the other hand, is still capturing the world's headlines with achievements that become progressively more spectacular.

The Atlas " family " of launching vehicles; in the top left-hand corner is a diagram of the Project Mercury capsule.


PITCH AND YAW JETS
HORIZON SCANNER
NAVIGATION PERISCOPE
PARACHUTE
HEAT SHIELD
ROLL JETS
RETRO ROCKETS
CAPSULE
107' 8"
99' 4"
94' 6"
88' 2"
75' 10"
ATLAS "D"
MERCURY
ATLAS-ABLE
ATLAS-AGENA
ATLAS-CENTAUR

The United States set the pace in the race to the Moon, by launching its Pioneer 1 space probe on October 11, 1958. The probe fell back to Earth after covering more than 70,000 miles. Pioneer 2 reached out only 970 miles and Pioneer 3 some 63,600 miles. Once again, a bold venture was to meet with disappointment and frustration, for on January 2, 1959, Russia joined in with *Lunik* 1 and achieved her traditional success—or did she?

Part of the payload of *Lunik* 1 consisted of the metal emblems illustrated on page 14, which implies that Soviet scientists may have hoped to plant the hammer and sickle firmly on the Moon in that first week of 1959. Instead, the *Lunik* passed by the Moon and went on to enter an orbit round the Sun, becoming its tenth planet.

America achieved a comparable success with Pioneer 4 two months later, but since then it has been Russia all the way. On September 14, 1959, *Lunik* 2 impacted on the Moon and man had made his first physical contact with another body in space. Less than a month later, the robot photographer *Lunik* 3 had passed around the Moon, photographed the far side which has never been seen from Earth, and sent back the pictures across 300,000 miles of space.

Since then America has reached out towards Venus with Pioneer 5; but the public understands Moon impacts and photographs far better than the kind of information obtained by such devices. Furthermore, the imminence of attempts to put a man in orbit promises more excitement than any instrumented probe.

As in the case of Vanguard, America captured all the advance notices with a high-pressure publicity campaign for her Project Mercury man-in-space programme. Once again, Russia has stepped smartly into the lead so far as the public is concerned by launching into orbit what is potentially a man-carrying satellite, in the shape of *Sputnik* 4, and following it up with *Sputnik* 5, the " flying Noah's Ark ". By bringing back its living cargo safe and sound this has truly opened the door to human space flight.

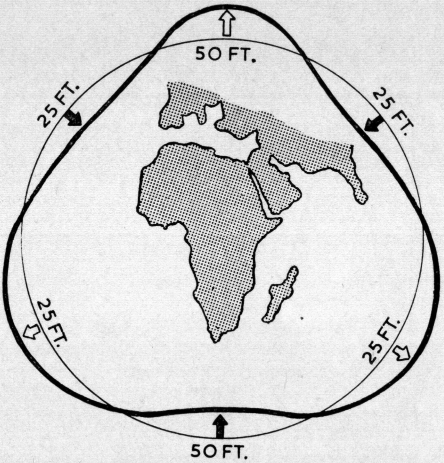
So much has happened in three years that today's predictions are likely to be overtaken by tomorrow's achievements; but America has issued a " timetable" of its space projects to show how it hopes to progress steadily over the next decade.

It will give its astronauts preliminary experience of rocket flight in 1960, by firing them down the Atlantic missile range in capsules carried by " old reliable", the Redstone. Then will come the first orbital flights under Project Mercury, followed by unmanned and manned reconnaissance journeys to the Moon and planets and, finally, the great adventure of landing a man on the Moon. Yet " finally " is hardly the word in this context, for even this will be but the start . . . .

Keep your record up to date here

Satellite Name	*Date*	*Country*	*Weight*	*Data & Remarks*
Courier 1–B	4.10.60	U.S.A.	500 lb.	Military communications satellite launched by a Thor-AbleStar. Sphere, 51 in. diameter.

Study of irregularities in the orbit of the tiny U.S. 3¼ lb. Vanguard 1 satellite indicated that the Earth is slightly "pear-shaped".



PUTTING SPACE TO WORK

WHAT benefit has been gained from this intense astronautical activity? What return has been received from the fantastic outlay of money?

It is too early to provide a simple answer. Most of the experiments have been directed towards pure research—that is, obtaining knowledge for the sake of knowledge and not with the thought of immediate practical benefit. In this respect, some scientists consider that we have learned more about the universe in the three years that have passed since *Sputnik* 1 went into orbit than in the three centuries since Galileo developed the telescope.

The first new fact about space was soon learned from *Sputnik* 1, which radioed data to show that the atmosphere at high altitudes is up to nine times denser than had been thought.

Satellites have also taught us new facts about the Earth upon which we live. For example, study of the orbit of Vanguard 1, the tiny 3¼ lb. grapefruit-sized U.S. satellite, showed that sometimes it moved a little slower than expected, sometimes a little faster. Since the speed of a satellite is governed by the Earth's gravitational pull, the changes in speed were interpreted to mean that gravitation over broad areas varies in an unexpected manner.

The variations were carefully measured and the shape of the Earth "adjusted" until the gravitational pull matched that indicated by the speed of the satellite. The result shows that the Earth is slightly pear shaped. There is a 25 ft. deep " neck " midway between the equator and the North Pole, and a similar-sized bulge towards the South Pole. The pear shape is completed by a 50 ft. hump at the North Pole and a 50 ft. depression at the South Pole.

Vanguard 1 also showed that the Earth does not bulge at the equator as much as geologists had previously estimated it would if the Earth were a soft plastic. Some unknown forces must be supporting the bulges and holding in the equator, and it may mean that the Earth's mantle—the 1,800 mile thick layer below the crust—is not as plastic as had been thought. It may have mechanical strength, like concrete.

Of more practical interest, Vanguard 1 also enabled the location of a number of remote Pacific Islands to be determined more accurately.

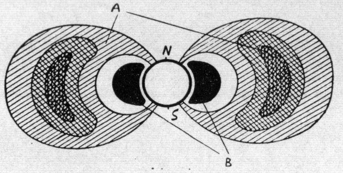


Fig. 1

Early major discovery by satellites was the existence of two doughnut-like belts of intense radiation round the Earth. Maximum intensity is such that a space traveller would absorb the safe weekly dose in a few hours. However, Earth's magnetic field causes two areas almost free of radiation around the magnetic poles.

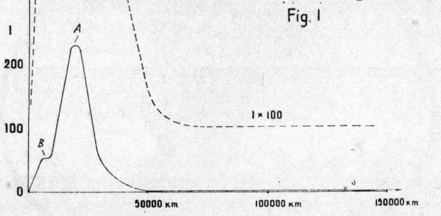


Fig 2

In this graph, prepared from data sent back by the Russian moon probe **Lunik 1,** *the continuous line shows the level of radiation up to* 90,000 *miles from the Earth. The dotted line shows the lower levels multiplied by* 100.

From Explorer 1, the first U.S. satellite, came data indicating the existence of immense radiation belts surrounding the Earth. When this satellite went into orbit it was noticed that as it climbed to its farthest point from the Earth the telemetered data concerning the intensity of radiation up to 400 miles was in close agreement with that predicted. Around 600 miles, however, the signals ceased abruptly.

Disappointed, U.S. technicians assumed that somehow the equipment had failed, for it was most unlikely that a radiation-free belt existed at that height. To their astonishment, when the satellite came round the second time, telemetered data was again received. But once again, as the satellite climbed to 600 miles, the transmission ceased. This procedure was repeated during orbit after orbit.

Puzzled, Dr. James A. Van Allen, who was responsible for the instrumentation on board the Explorer 1, subjected a spare Geiger tube of the kind fitted in the satellite to radiation bombardment in the laboratory. The strength of the bombardment was started at 30 to 40 counts per second, the intensity reported back from 200 to 300 miles. Gradually the intensity was increased until, at a count of 35,000 per second, the Geiger tube " went off the air "; it was so " choked " that it could not report its findings. From this experiment, it was conjectured that Explorer 1 must be passing through radiation of an intensity equal to at least 35,000 counts per second, or 1,000 times greater than had been expected.

If the radiation were X-rays, this would represent an intensity of 0.06 roentgens per hour, five hours of which would be equivalent to the maximum weekly dosage permissible for industrial workers. On this basis, too, it would not be safe to remain 1,000 miles out in space for more than five hours without adequate shielding.

To find out more about this mysterious belt of radiation, which made the outlook for manned interplanetary flight rather depressing, the U.S. prepared another Explorer, specially instrumented to investigate radiation.

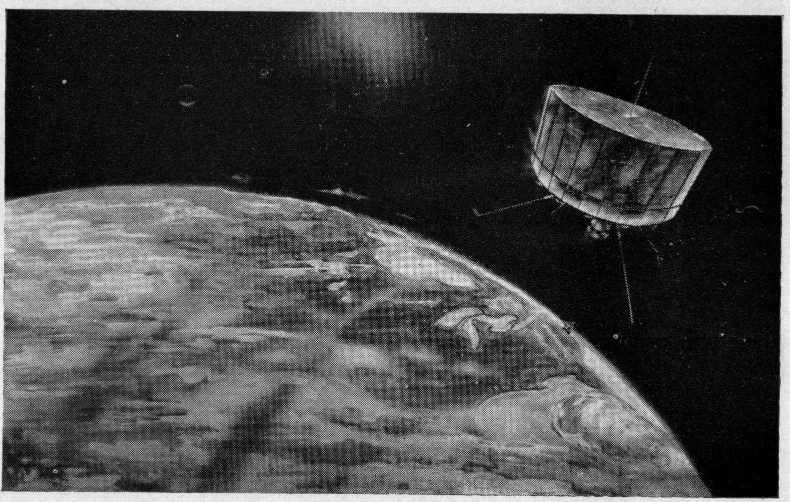
Explorer 2, fired in March 1958, malfunctioned and failed to orbit. Explorer 4, launched four months later, contained even more specialised equipment designed to distinguish between hard and soft radiation. Shielded Geiger counters were intended to count radiation at extremely high levels without blacking out. Data received from this satellite seemed to confirm that a human exposed to the maximum radiation for a few days would die.

In December 1958, the U.S. Moon probe Pioneer 3, although failing to reach the Moon, provided data on a second radiation belt beyond the inner layer, with a relatively low-intensity slot between. Van Allen concluded that this outer belt was made of weaker particles, presumably protons and electrons, that had come from the Sun. These deductions were confirmed by Pioneer 4, which by-passed the Moon and is now in orbit round the Sun. Tracked 400,000 miles out into space, this indicated that the outer radiation belt is not of constant intensity. After five days of intense solar activity the radiation activity was up to ten times that reported by Pioneer 3; the cause seemed to be fresh clouds of radiation surging out from the Sun.

This information may, in the future, be put to practical use. It has long been known that solar activity affects the Earth. For example, a solar flare observed on February 10, 1959, was followed by magnetic storms, radio disturbances, record high Arctic temperatures and freezing rain and snow throughout the United States. Further knowledge of these phenomena may, in time (according to one U.S. scientist), lead " to a distant satellite observatory, able to predict the arrival of a cloud of solar particles in time to light the smudge pots protecting the fruit in Florida."

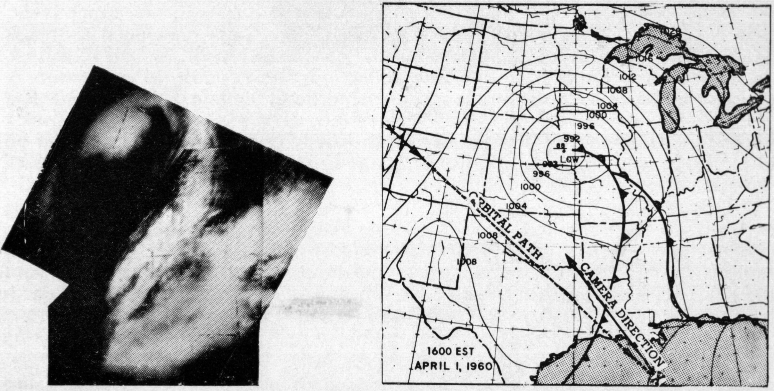
Information sent back by the deep-space-investigating probe Pioneer 5 has altered many previously-held theories about interplanetary space. About 25,000 miles out, it detected a current of electricity, carrying perhaps 5 million amperes, flowing round the Earth. Soon afterwards the probe's magnetometers

Artist's impression of how the U.S. weather satellite Tiros 1 *looks in orbit. It is depicted far above the Pacific; at bottom left is the interrogating station at Kaena Point, Hawaii, and on the horizon Fort Monmouth, New Jersey.*



showed that the Earth's magnetic field boundary ends at about 56,000 miles, or about twice as far as had been calculated. Beyond this it detected a cloud of electrified solar gas moving towards the Earth, and reported the first drop in cosmic ray count associated with a solar cloud.

Still further out, Pioneer 5 has reported a weak magnetic field that apparently


1016
1012
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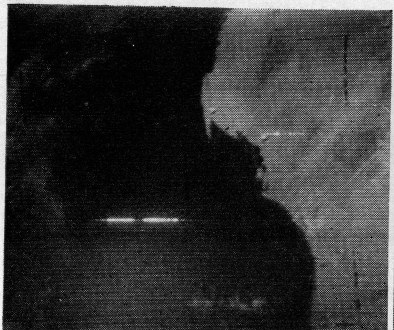
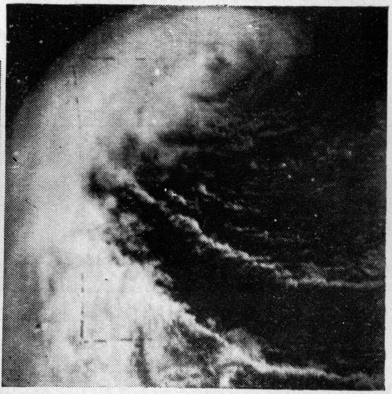
1008
ORBITAL PATH
CAMERA DIRECTION
X
1600 EST
APRIL 1, 1960

A well developed storm over Nebraska photographed by Tiros 1 on April 1, 1960. The centre of the storm is the circular cloud mass in the upper part of the picture. The appropriate surface weather map is shown to the right; X marks the point from which the picture was taken.

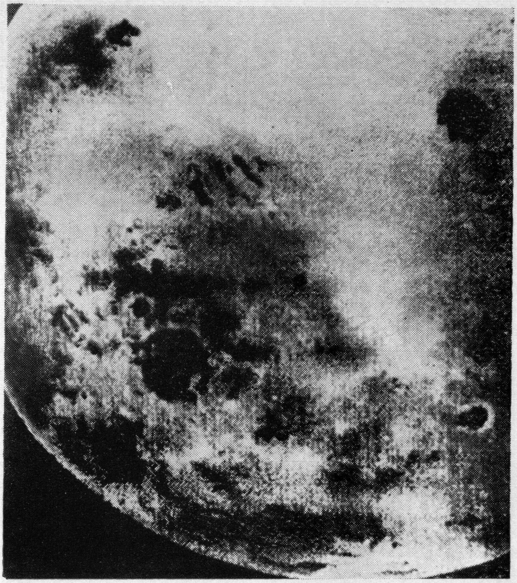


This picture of Cape Blanco on the western coast of French West Africa was recorded by the low-definition, wide-angle camera of Tiros 1.



Typhoon in the South Pacific, about 1,000 miles east of Brisbane, Australia. The picture was stored on magnetic tape within the satellite for three orbits until it came within transmitting range of the data-receiving stations on the ground.

First photograph of the normally-hidden rear face of the Moon obtained by the Russian Moon probe **Lunik 3.** *A provisional analysis indicates fewer craters than on the visible face, although this impression may be due to the fact that the Sun was almost overhead when the picture was taken, giving an intense light on the surface.*
The earlier Russian probe, **Lunik 2,** *discovered that the Moon has no magnetic field.*



has nothing to do with the Earth. What causes it? Perhaps it is a ring current in the Sun's outer " atmosphere ", which is now known to extend beyond the orbit of Earth; perhaps it is the field of the solar system itself, or even of the basic galaxy. This remarkable satellite continued to telemeter back such data up to a record distance of 22,500,000 miles.

Abstruse information of this kind is, of course, of immense interest to space scientists, but it is hardly likely to excite the average person.

However, some satellites are already providing information of which the practical benefit is apparent to all. One such vehicle is Tiros 1, the U.S. weather-reconnaissance satellite. From a near-circular orbit some 450 miles above the surface and equipped with two television cameras, one covering an area 800 miles square and the other an area 80 miles square in greater detail, Tiros has transmitted back thousands of photographs of cloud formations. An initial study of these shows that the cloud systems are much more highly organised than previously supposed. Some non-tropical storm clouds have a banded-spiral structure. Off Hawaii, Tiros relayed back pictures of a gigantic cyclonic formation 2,000 miles across, a phenomenon never before observed.

When meteorologists have learned the new art of interpreting these space-pictures, and more advanced Tiros-type satellites are in orbit, this should revolutionise weather forecasting and make it much more accurate. This is obviously of practical interest to the world's flying, farming and pleasure-seeking peoples.

Another satellite experiment which is planned to be of immediate practical use is the U.S. Transit 1-B. While listening to the signals from *Sputnik* 1, a pair of young scientists at the Johns Hopkins University experimented with tracking the Russian satellite by means of the Doppler effect.

This is a common phenomenon; sound waves from a moving object increase in frequency as the source of the sound approaches an observer, decrease as it moves away. The popular example is the locomotive whistle which seems to rise and fall in pitch as the train goes by. Similarly the signals from a satellite increase in frequency as it approaches and diminish as it recedes. The scientists tracked the *Sputnik* with remarkable accuracy. From this it was argued that if satellite positions could be plotted from the Earth, then Earth positions could be plotted by readings from a satellite!

This is what the Transit system is intended to do. By measuring the rate of change in frequencies, it is possible to calculate the exact distance from the satellite. The developed satellites will also indicate exactly where they are at any moment; with these two items of information a computer should be able to give a navigational fix, accurate to within a quarter of a mile, every 90 minutes.

Although it is being developed primarily for military purposes, merchant ships will be able to avail themselves of the Transit service if they so desire. All that will be needed will be a whip aerial and a low-cost receiver and computer.

But, for the most part, satellites are designed purely to seek scientific data. Space research is enabling us to get above the Earth's atmospheric blanket which shields us so effectively from most of the realities of the universe. It is impossible to say what knowledge will be gained, or what the benefit, if any, will ultimately be.

Because of this many people find it difficult to understand why vast sums of money should be allocated so readily to " useless " experiments, when there are so many pressing everyday problems in dire need of financial assistance.

One good answer is that nearly all the technical devices on which the culture and economic strength of the great powers are based can be traced back directly to fundamental scientific research which was initiated originally without thought of practical benefit.

This remarkable photograph was transmitted from Hawaii, via the Moon, to Washington, during a public demonstration of the U.S. Navy's communication Moon Relay system on January 28, 1960. *Messages can only be sent when the Moon is above the horizon at both terminals. Communications satellites will permit interference-free transmission at all times. Carrier in the picture is the U.S.S.* **Hancock,** *with the crew spelling out " Moon Relay ".*

BRINGING THEM BACK ALIVE

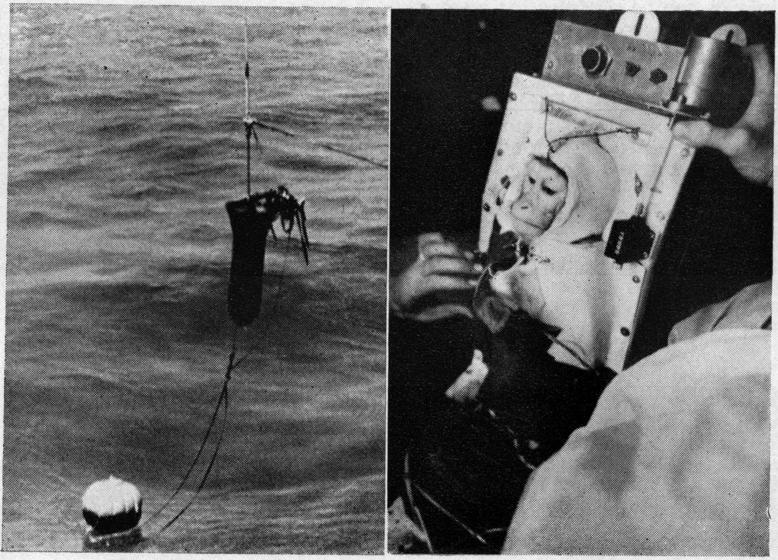
THE photograph which forms the frontispiece of this *ABC* shows a Soviet trainee astronaut and a dog, in pressure-suits, on the threshold of an altitude test chamber. The original Russian caption states " Fido goes first ", and sets the theme for the whole adventure of space travel. There is nothing new in this. Back in 1783, when the Montgolfier brothers in France invented the hot-air balloon, they gave the dubious honour of being the first living creatures to fly in it to three animals—a sheep, a duck and a chicken. Not for another four weeks did a man venture into the air.

As it was in the beginning, is now, and presumably ever shall be, for animals are also preceding men on the first journeys into space.

It surprises most people to learn that an Italian named Claude Ruggieri fired a number of small animals such as rats and mice into the air inside large rockets more than a hundred years ago. When the rockets were burned out, a parachute opened and lowered the animals slowly and gently back to Earth.

This was comparatively easy, because the distance they travelled was small

Left: *recovering the Thor-Able nose cone in the South Atlantic: the flotation bag kept the cone afloat until the " rescue " ship arrived.* Right: *Monkey Able in his " space couch " prior to launching into space with a Jupiter-C.*



and, of course, they were not space travellers as their rockets stayed within the atmosphere.

With the dog *Laika,* in 1957, it was different. Her *Sputnik* flew far out into space at a speed of 17,500 m.p.h. The Russians had not then solved the problem of getting such a large object back into the atmosphere without its being burned up like a shooting star (see page 30 for more about this). So *Laika* gave her life as part of the price of progress.

Such incidents must cause sorrow to all who love animals: but the only alternatives are to let men take the risks instead, or to abandon all possibility of journeying into space. The latter is unthinkable; while those irrational enough to suggest that men should have the courage to do their own adventuring forget that this happened in the case of powered aeroplane flight. There was no shortage of men of spirit to test the first frail stick-and-wire flying machines and their bravery was exemplified by Otto Lilienthal, the great gliding pioneer who proved conclusively that heavier-than-air flight was possible. After crashing in 1896, he whispered " Sacrifices must be made ", and then died.

Animals could not fly aeroplanes and so save men like Lilienthal from some of those early hazards. But they can travel by themselves in rockets, because even the most advanced man-carrying rockets yet devised will be controlled from the ground during at least the early stages of take-off. In most cases, including the U.S. Project Mercury manned satellite programme, control from the ground can be continued throughout the entire flight if necessary.

To take advantage of this by sending up animals instead of men is common sense. It enables us to be certain that the launching, control and landing technique works perfectly before risking a human life. By measuring and recording the effects on the animals of acceleration, weightlessness, radiation and other conditions, we can deduce what the comparable effects would be in the case of a man. Nor does this research stop after a successful flight. The animals can be observed for many months subsequently, to check whether or not there are any after-effects, such as radiation sickness.

How far have flights of this kind enabled us to progress towards the day when an astronaut will set out on the most exciting and awe-inspiring journey in history?

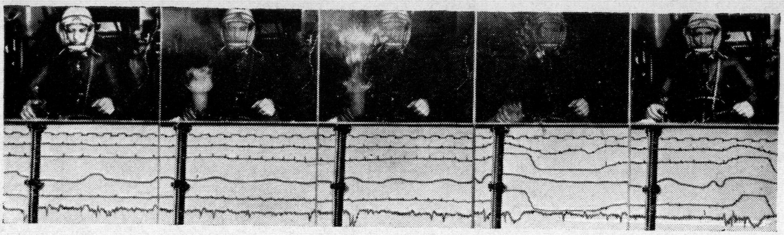
We can only guess at the answer, because, although the Americans have given precise details of their man-in-space programmes, the Russians are announcing only what they have done, as opposed to what they hope to do in the future.

Sputnik 5, the " flying Noah's Ark ", showed that they are capable of putting a man-carrying capsule into orbit and of getting it back again.

We have photographs showing Soviet astronauts under training, and there is little doubt that Russia hopes to be the first to put a man in orbit. At present, however, we can learn more about future prospects from studying the various U.S. projects, of which the most advanced are the X-15 flight programme and Project Mercury.

The North American X-15 is a rocket-powered research aeroplane which is launched from a B-52 mother-plane at around 40,000 ft. and then streaks up. ward under the thrust of the most powerful engine ever put into a piloted aircraft- Already, by mid-1960, it had reached speeds of nearly 2,200 m.p.h. during test flights. Eventually, it is expected to fly at around 3,600 m.p.h. (5½ times the speed of sound) and to climb to between 50 and 100 miles above the Earth.

At such heights, it will be above virtually all of the atmosphere and its pilot will experience the effect of " weightlessness " for several minutes at a time.



The graphs below each picture show changes recorded in the functioning of the heart, lungs and muscles under simulated space-flight conditions.

The reports of his reactions to this will be of great importance, because it is impossible to reproduce this condition on the ground. Some pilots who have put their aircraft into brief ballistic trajectories for ten to thirty seconds have felt severe nausea. Others claim to have enjoyed the sensation. But we still don't know how they would react to hours of it and the most hopeful sign is that " weightlessness " did not seem to worry the Soviet space-dogs overmuch.

No less important is that we shall learn from the X-15 quite a lot about bringing winged aircraft back into the denser atmosphere. It is made of materials like stainless steel and titanium, and has an outer skin coating of a special nickel alloy to help it withstand the tremendous frictional heat built up during re-entry. Another interesting feature is that it has tiny rocket jet nozzles built into its nose and wing-tips to provide control at extreme heights where normal aerodynamic controls would be useless. Such devices and techniques, once proven on the X-15, will be available for future Earth-to-space craft like manned reconnaissance vehicles or ferry ships to carry men and supplies to orbiting space-stations.

Project Mercury is even more exciting than the X-15 programme, because it aims at putting a man in orbit during 1961. It was started in October 1958, since when the two major phases—astronaut training and " hardware " development—have proceeded simultaneously.

The first step was to find a suitable group of candidates for the great adventure. NASA fixed as basic requirements that the men must be fully qualified military test pilots with at least 1,500 hours of flying time, a height of not more than 5 ft. 11 in., aged under 40, and completely fit. A degree or equivalent in engineering or science was considered essential to ensure that the men would be able to cope with the technical problems encountered during training and the actual flight.

More than 100 men met these requirements, so a thorough programme of elimination was started. Typical of the physical tests were that each man was made to walk on a moving platform which got steeper at the end of every minute, to plunge his feet into a tub of ice water, to lay for 25 minutes on a steeply-tilted table, to spend two hours in a room at a temperature of 130°F., to try to keep a rotating and rocking chair on an even keel by means of a joystick whilst blindfold, and to spend three hours alone in a dark soundproof room. During each of these tests his reactions were noted.

Then came the intelligence tests, and many critics began to feel that all this was going a bit far, especially as the Mercury flights will normally be controlled mainly from the ground. But NASA considered its high standards essential, and it would certainly be difficult to find men better qualified for the difficult and rather frightening task ahead.

Soviet astronaut Gennady Mihailov preparing for " take-off " in a pressure chamber. Protective suiting will keep his blood from boiling under conditions of zero pressure.

Mihailov studies with his colleagues graphs showing the results of tests carried out in preparation for manned space flight.

The centrifuge test demonstrates the effects of high g factors upon the astronaut during travel in space.

The names of the final seven from whom the first U.S. astronaut will be chosen are Captains Leroy Cooper, Donald Slayton and Virgil Grissom of the U.S.A.F.; Lt. Cdrs. Alan Shepard and Walter Schirra and Lt. Malcolm Carpenter of the U.S. Navy; and Lt. Col. John Glenn of the U.S. Marine Corps. Their ages range from 33 to 39 and all are married, with children.

Over the past 18 months, up to the Summer of 1960, they have undergone rigorous training. They have, for example, spent days on special low-residue diets, have made high-*g* rides in a centrifuge to simulate the forces they will feel during take-off and deceleration, have spent long periods in a special three-dimensional trainer, learning to operate controls such as those for the retro-rockets, and have tried getting out of a dummy Mercury capsule in the water.

While they have been doing so, Soviet astronauts like Gennady Zavodovsky and Vladimir Ilyushin have been training in a similar way for a similar mission. But, whereas we know nothing of the space-ships in which they will travel, we know a great deal about the Mercury capsule, which is illustrated, with a diagram of its trajectory, on page 28.

Designed by the McDonnell company, the capsule is shaped rather like an old-fashioned circular TV cathode-ray tube, with an extended girder-like stem. The pilot will recline on a couch contoured to his individual shape, with his back against the curved leading face, which has a diameter of about 6 ft. As well as forming the heat-shield during re-entry, through the ablative technique of burning away layers of special plastic, this face carries the jettisonable retro-rocket pack, the forward-firing thrust of which will slow the capsule when the time comes to spiral down out of orbit. The plan is for the capsule to end up in the sea, sending out radio beacon signals and using other devices to attract the aircraft and ships which will be at hand to locate and retrieve it. For this reason flotation bags are fitted; but the leading face is made of crushable aluminium honeycomb, to absorb the shock of a landing ashore.

The pilot will have the choice of manual or automatic control during orbital flight and will have a gadget called an Earth Path Indicator to tell him where he is. Built by Minneapolis-Honeywell, this consists of a box containing a slowly-turning globe which will duplicate the position of the Earth under the capsule as it completes its three-orbit 4½-hour flight at 17,000-18,000 m.p.h.

The girder structure extending beyond the recovery parachute container is an emergency escape system for use if anything goes wrong during the launch or before orbital altitude is reached. It has a powerful rocket motor built into the end compartment to carry the capsule up and away from the booster to a safe height, from where it would be lowered by the normal parachute recovery system.

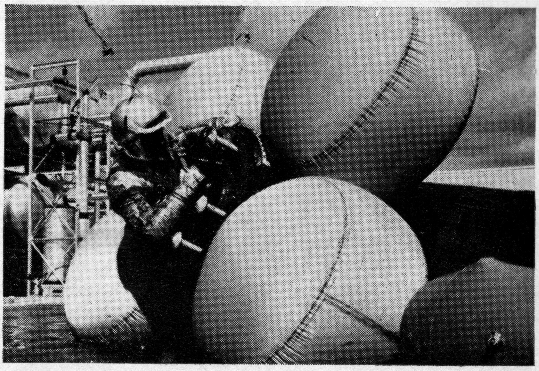
Nothing should go wrong, because tremendous patience and care have gone into the design, construction and testing of every part of the capsule and its launching system. Following many hours of wind-tunnel tests, dummy capsules have been launched with the aid of Little Joe and Big Joe (Atlas) boosters. These tests have proved the efficiency of the escape system and have shown that the capsule is able to re-enter the atmosphere from a height of 100 miles safely and without tumbling at a velocity approaching orbital speed.

The next step will be to fire genuine capsules down the Atlantic missile range on the nose of Little Joe and Redstone boosters. After a few instrumented flights, a chimpanzee will become the first living creature to fly in one of these capsules. The astronauts are scheduled to follow before the end of 1960. At about the same time, an instrumented capsule will be fired into orbit by an Atlas booster, as a final test of the recovery system.

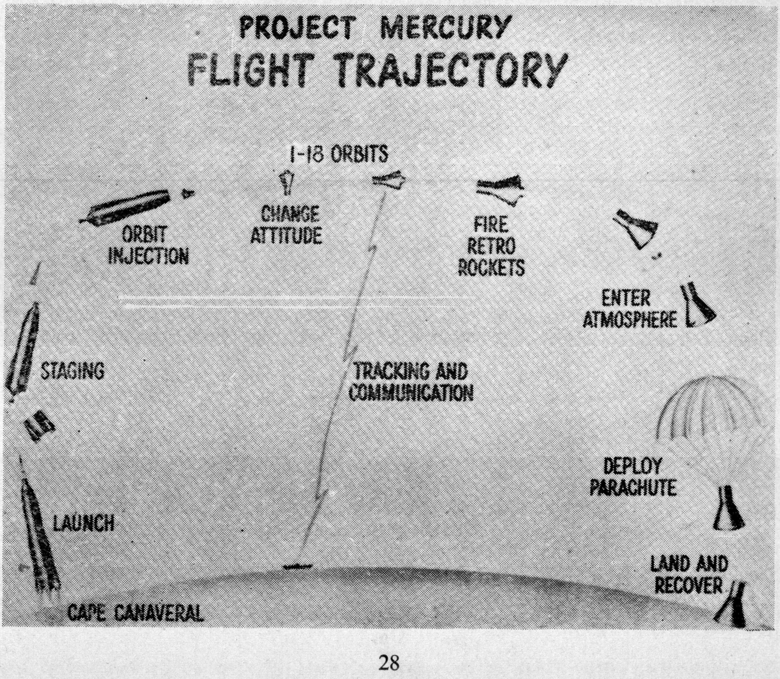
Early in 1961 another chimpanzee will be sent on a fully representative orbital flight as a dress rehearsal for the moment when one of the seven Mercury astronauts will climb into his tiny capsule at Cape Canaveral and prepare for the most fantastic journey on which man has yet embarked.

After that........the Moon.

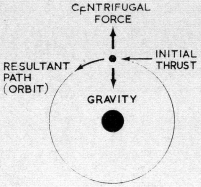
When? This may depend on what we learn about the hazards of space flight from Project Mercury and from the satellites and space probes that are being launched in ever-growing numbers. But the Americans will have boosters capable of soft-landing a nine-ton payload on the Moon by the late sixties. Getting back again is, of course, another matter!

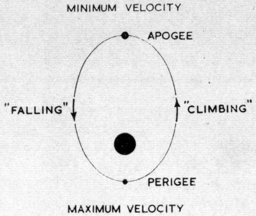


Right: *one of the U.S. Project Mercury team practises escape from a dummy capsule in the water. The diagram below shows how the satellite's separation and recovery mechanism will be operated.*


PROJECT MERCURY
FLIGHT TRAJECTORY
1-18 ORBITS
ORBIT INJECTION
CHANGE ATTITUDE
FIRE RETRO ROCKETS
ENTER ATMOSPHERE
STAGING
TRACKING AND COMMUNICATION
DEPLOY PARACHUTE
LAUNCH
LAND AND RECOVER
CAPE CANAVERAL

HOW AND WHY





How a satellite stays up

ARTIFICIAL satellites remain aloft for the same reason that the Moon and the planets remain in their orbits: a state of balance exists between gravity, trying to tug them inwards, and the centrifugal force trying to make them fly off into space.

We all know that the harder you throw a stone, the further it will travel before falling to Earth. If you can imagine your strength greatly increased so that you could throw a stone at a speed of 15,000 m.p.h., it would cross the Atlantic Ocean quite easily before the Earth's gravity pulled it down. Now imagine being able to throw the stone a little faster—say at 18,000 m.p.h.—what would happen then?

The stone would again cross the ocean, but this time it would travel much further than it did before. Assuming in this example that there were no atmospheric resistance, the stone would continue moving subject only to two forces: centrifugal and gravity. These two opposing forces would balance each other, so that the stone would " overshoot " the Earth and keep on " falling " until it came back to where it started. It would still be travelling at the original speed of 18,000 m.p.h., so around it would go again. As the scientists say, the stone would be in orbit.

Satellites, of course, must first be lifted beyond the reach of effective atmospheric resistance, turned parallel to the surface of the Earth and then accelerated to a speed at which the centrifugal force exactly balances gravity. In this example the satellite path would be circular, but it need not be. In fact, most satellites, artificial and natural, have elliptical orbits.

In an elliptical orbit the " balance of power " is constantly shifting from gravity to the centrifugal force, and the speed of the satellite consequently varies.

The key points in the satellite ellipse are the apogee, the point farthest from the Earth, and perigee, the point closest to the Earth. As the satellite " climbs " to apogee it gradually loses velocity because it is actually travelling away from the Earth, against gravity. At apogee its velocity, and therefore its centrifugal force, has reached a minimum, whereupon gravity starts drawing the body Earthward.

Throughout the next half-revolution around the Earth, the satellite drops through a long curve, picking up the velocity it lost in the outward swing. At perigee, moving at maximum speed, it has built up enough centrifugal force to overcome gravity and starts shooting off into space again.

As it moves back to apogee, it once again loses its momentum, steadily losing the advantage it gained in " falling " to perigee. The process is repeated over and over again. It will continue indefinitely if no resistance is met, and if the original velocity was sufficient to maintain an orbit.

As the centrifugal force of a satellite in a circular orbit must just counter-balance gravity, it follows that as gravity varies with distance, a certain velocity is required to orbit at a particular altitude. This is known as orbital velocity. Gravity decreases with distance, so the higher the altitude, the lower the speed needed to remain in orbit. At an altitude of 300 miles an orbital speed of 17,060 m.p.h. is required; one thousand miles up, the speed has dropped to just under 16,000 m.p.h.; at 5,000 miles it is under 12,000 m.p.h. At a distance of 22,289 miles the orbital velocity is slightly over 6,800 m.p.h., at which a satellite would travel around the Earth once every 24 hours. If the satellite were launched along the Equator it would always be travelling above the same point on the surface and would thus appear to remain stationary in the sky.

The Moon, nearly a quarter of a million miles away, maintains its orbit at a speed of only 2,268 miles per hour.

Height above surface of Earth	Orbital speed	Orbital period	
miles	*m.p.h.*	*Hr.*	*min.*
100	17,450	1	28
200	17,250	1	30
300	17,060	1	34
400	16,850	1	37
500	16,660	1	41
600	16,450	1	45
700	16,300	1	48
800	16,140	1	51
900	15,960	1	55
1,000	15,780	1	59
1,500	15,050	2	17
2 000	14.415	2	36
3,000	13,350	3	15
4,000	12,485	4	0
5,000	11,750	4	45
10,000	9.410	9	20
20 000	7,180	21	0
22,289	6,872	24	0

The orbital speed of a satellite is determined by its height above the Earth. The table gives the approximate orbital speeds and periods of revolution for various heights.

Unless a satellite is orbiting at a minimum height of several hundred miles, it will be in constant collision with minute particles of atmosphere. Eventually, this atmospheric friction causes a slight decrease in the satellite's velocity, the drop in speed brings a corresponding drop in centrifugal force and the path of the satellite curves downwards under the force of gravity.

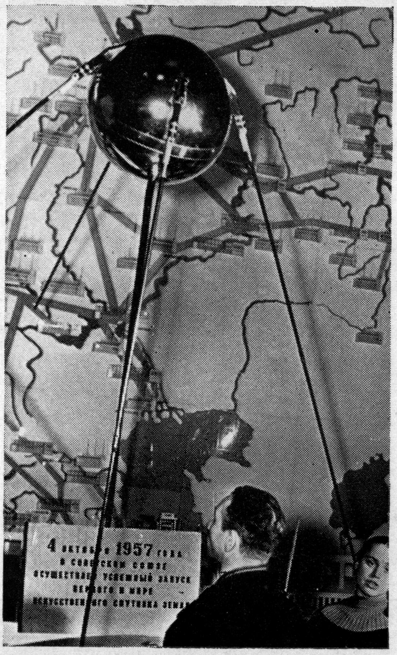
Now the satellite picks up speed, for two reasons: a falling body accelerates and, as explained previously, speed in an orbit increases as the altitude becomes lower. The satellite actually accelerates to *more* than its previous speed, and centrifugal force moves it outward again. But increased speed in the heavier atmosphere multiplies drag, and the satellite starts slowing down before regaining its original course. It again loses altitude.

The process continues, the satellite gradually dropping closer to the Earth. Eventually atmospheric density increases so rapidly that deceleration due to drag overcomes acceleration due to gravity. Orbital movement is broken up and the satellite begins diving to Earth. Atmospheric friction then literally ' melts ' the satellite, due to the intense heat generated, and complete disintegration occurs.

Satellites in elliptical orbits, if subjected to drag, gradually spiral into near-circular orbits before following this procedure.

SATELLITES

Sputnik 1



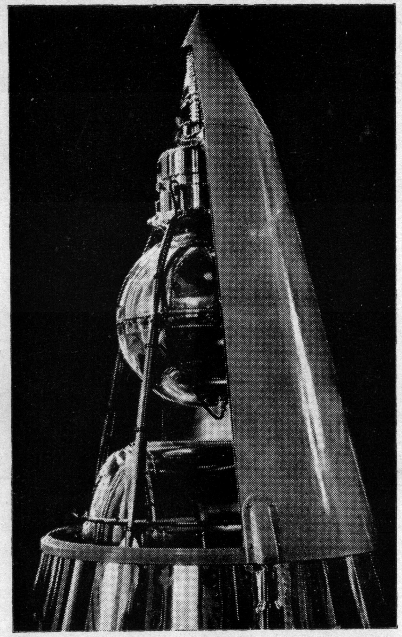
LAUNCHED BY: U.S.S.R.
LAUNCHING VEHICLE: Modified Soviet IRBM?
DATE: October 4, 1957.
LIFETIME: Three months; down January 4, 1958.
SHAPE AND SIZE: Sphere, 22.8 in. diameter.
WEIGHT: 184 lb.
INITIAL ORBITAL HEIGHT: Apogee 588*; Perigee 142 miles.
ORBITAL INCLINATION: 65° to Equator.
EXPERIMENTS: Measurement of pressure and temperature. Other data may have been obtained.
* *Height differs from figure given in initial Russian announcement of satellite: source of data, R.A.E.*

Remarks:

World's first artificial satellite. Much heavier than weight previously considered reasonable for this important first step in astronautical development. Most of the weight is assumed to have been made up by the chemical batteries powering the radio. Transmissions, on 20.005 and 40.002 M/c., stopped on October 27, 1957.

The satellite was constructed of aluminium alloy, with a polished and specially treated surface, and was filled with nitrogen gas, presumably to help dissipate the heat generated by the electrical equipment.

Observations of changes in the satellite's orbit provided the first evidence that the atmosphere at heights of about 150 miles is from 4 to 9 times as dense as had been estimated.



Sputnik 2

LAUNCHED BY: U.S.S.R.

LAUNCHING VEHICLE: Modified Soviet ICBM?

DATE: November 3, 1957.

LIFETIME: 5½ months; down April 14, 1958.

SHAPE AND SIZE: Conical container, 7 ft. long by 3 ft. 6 in.

WEIGHT: 1,120 lb.

INITIAL ORBITAL HEIGHT: Apogee 1,038; Perigee 140 miles.

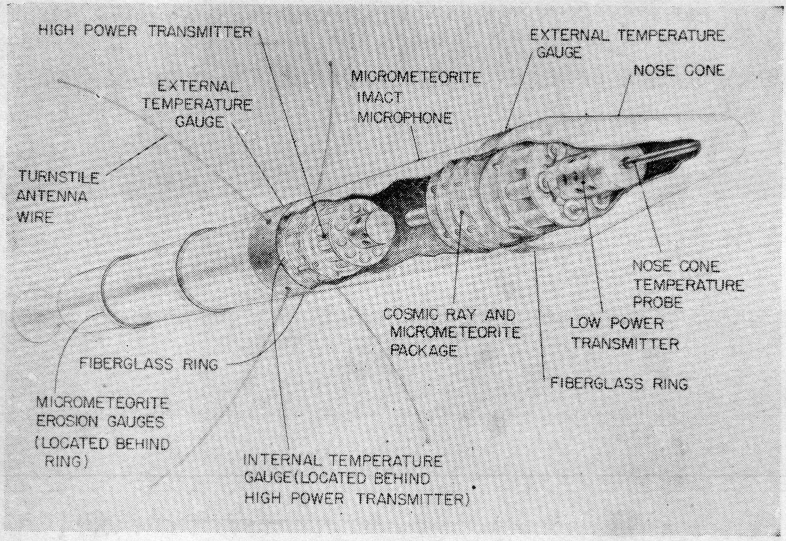
ORBITAL INCLINATION: 65° to Equator.

EXPERIMENTS: Effect of space environment on live dog carried in pressurised container: measurement of cosmic rays, solar ultraviolet and X-radiation, temperatures and pressures.

Remarks:

First experiment involving life in space, and a very ambitious one for incorporation in the second-ever artificial satellite. Reports indicated that the husky-type dog, conditioned to eat when a bell rang, survived its week's weightless journey through space without apparent harm. Very few genuine data have been released officially, but reports indicate that its pulse and breathing soon settled down to around their normal rates. The dog died when the air supply gave out.

Radio transmissions ceased after seven days; in view of the shortness of this period, some Western experts considered that it was due to equipment failure, and not planned.


HIGH POWER TRANSMITTER
EXTERNAL TEMPERATURE GAUGE
NOSE CONE
EXTERNAL TEMPERATURE GAUGE
MICROMETEORITE IMACT MICROPHONE
TURNSTILE ANTENNA WIRE
NOSE CONE TEMPERATURE PROBE
COSMIC RAY AND MICROMETEORITE PACKAGE
LOW POWER TRANSMITTER
FIBERGLASS RING
FIBERGLASS RING
MICROMETEORITE EROSION GAUGES (LOCATED BEHIND RING)
INTERNAL TEMPERATURE GAUGE(LOCATED BEHIND HIGH POWER TRANSMITTER)

Explorer 1

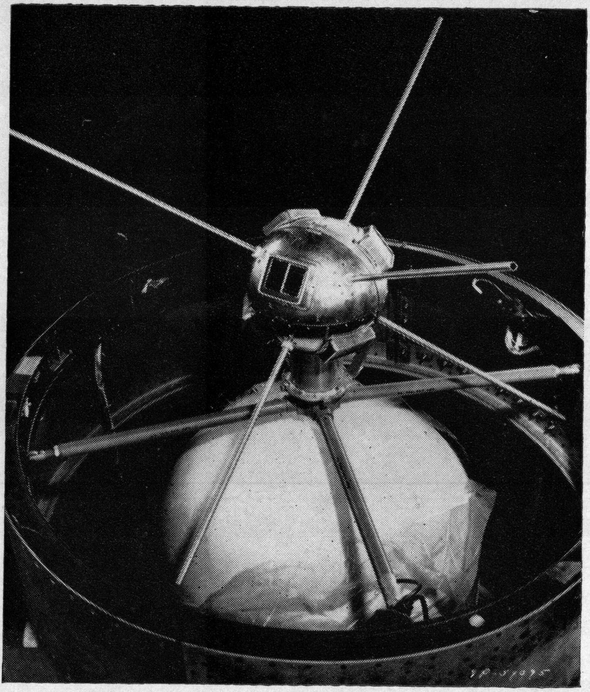
LAUNCHED BY: U.S.A.
LAUNCHING VEHICLE: U.S. Army 4-stage Jupiter C.
DATE: January 31, 1958. *LIFETIME:* 4-5 years (estimated).
SHAPE AND SIZE: Cylindrical; 6 ft. 8 in. long by 6 in. diameter.
WEIGHT: Total, 30.8 lb.
Equipment, 18 lb.
INITIAL ORBITAL HEIGHT: Apogee 1,573; Perigee 224 miles.
ORBITAL INCLINATION: 33° to Equator.
EXPERIMENTS: Measurement of cosmic rays, micrometeors and internal temperatures.

Remarks:

First U.S. satellite. Order to proceed given on November 8, 1957, as a " backstop " for the Vanguard satellite. Jupiter C launching vehicle is a special Redstone missile, modified to house larger fuel tanks containing Hydyne.

Transmissions on 108.00 M/c. at 10 M/w. ceased on May 23, 1958; those on 108.03 at 60 M/w. stopped on February 11, began again on February 24, finally ceased on February 28, 1958.

Although small by comparison with Soviet satellites, Explorer 1 discovered the now famous Van Allen radiation belts surrounding the Earth.



Vanguard

I

LAUNCHED BY: U.S.A.
LAUNCHING VEHICLE: U.S. Navy 3-stage TV-3.
DATE: March 17, 1958. *LIFETIME:* 1,000 years (estimated).
SHAPE AND SIZE: Sphere, 6.4 in. diameter.
WEIGHT: 3.25 lb.
INITIAL ORBITAL HEIGHT: Apogee 2,453; Perigee 409 miles.
ORBITAL INCLINATION: 34.3° to Equator.
EXPERIMENTS: Measurement of temperatures and geodetics.

Remarks:

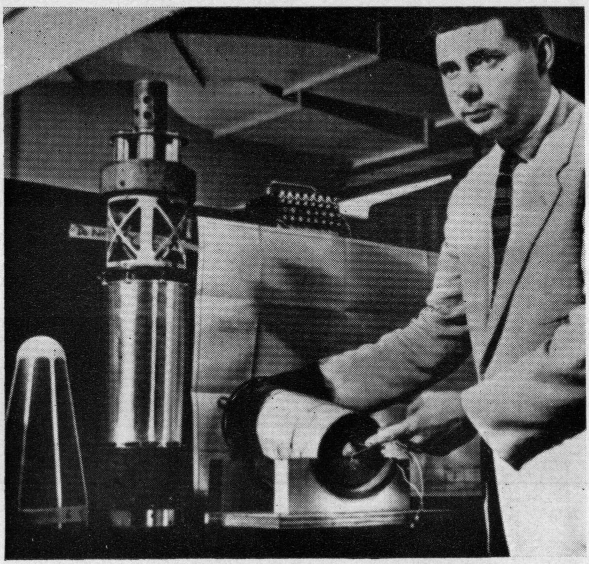
Intended as initial test satellite for Vanguard series. First satellite to incorporate solar cells to convert sunlight into electrical energy: at the time of going to press, 2½ years after launch, the cells were still functioning efficiently. The transmissions cannot be controlled from the Earth and the continuous signal sent out sometimes hinders the receipt of data from other satellites.

This tiny satellite was photographed on three separate occasions in 1959 by the Smithsonian Optical Tracking Station at Woomera, Australia, using a Baker-Nunn camera; the satellite was then 2,500 miles away. This feat has been described as comparable with photographing a golf ball from a distance of 600 miles.

Optical observations of the satellite's orbit have provided data on the exact shape of the Earth. Orbit is perturbed by sunlight pressure.

Explorer

3



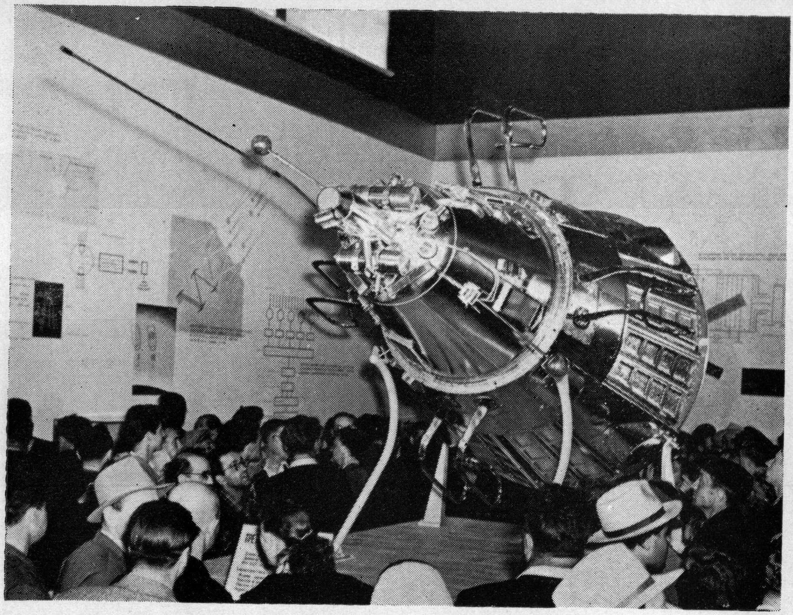
LAUNCHED BY: U.S.A.
LAUNCHING VEHICLE: U.S. Army 4-stage Jupiter C.
DATE: March 26, 1958. *LIFETIME:* Three months; down June 28, 1958.
SHAPE AND SIZE: Cylinder, 6 ft. 8 in. long by 6 in. diameter.
WEIGHT: Total, 31 lb.
Equipment, 18.5 lb.
INITIAL ORBITAL HEIGHT: Apogee 1,746; Perigee 121 miles.
ORBITAL INCLINATION: 33° to Equator.
EXPERIMENTS: Measurements of cosmic rays, micrometeors, internal and external temperatures.

Remarks:

Information recorded on a miniature tape recorder, weighing only $\frac{1}{2}$ lb. and 2.5 in. diameter, to reduce the current consumption of the high-power transmitter. Data recorded as satellite circled Earth; tape moving .005 in. per second. When interrogated, the recorder reversed, then sped through playback head to transmit data in a 5-second burst. Recorder was then reset for next orbit.

During the satellite's lifetime, radio transmissions became erratic, and suggestions were made that it may have been damaged by minute particles of a meteor swarm composed of debris from Halley's Comet. Earlier telemetered data indicated damage to the erosion grids used for measuring micrometeors; the cosmic ray measuring device behaved erratically to an extent that can be explained logically only by mechanical damage such as a loosened wire.

This satellite provided further information on the radiation belts discovered by Explorer 1.



Sputnik 3

LAUNCHED BY: U.S.S.R.
LAUNCHING VEHICLE: Modified Soviet ICBM?
DATE: May 15, 1958. *LIFETIME:* 23 months; down April 6, 1960.
SHAPE AND SIZE: Cone, 11 ft. 7 in. long by 5 ft. 8 in. diameter.
WEIGHT: Total: 2,925 lb.
Equipment: 2,134 lb.
INITIAL ORBITAL HEIGHT: Apogee 1,167; Perigee 135 miles.
ORBITAL INCLINATION: 65° to Equator.
EXPERIMENTS: Measurement of atmospheric pressure and composition; of concentration of positive ions, and of satellite's electrical charge. Measurement of tension of Earth's magnetic field; of intensity of Sun's corpuscular radiation; of composition and variations of primary cosmic radiation and of distribution of photons and heavy nuclei in cosmic rays. Detection of micrometeors and temperature measurements.

Remarks:

Very advanced and sophisticated satellite. Indications are that the complex equipment performed well during the planned lifetime. Radio transmissions, solar-cell powered, became ragged towards the end when the satellite exceeded its expected life (8,000 revolutions). Satellite orbited the Earth 10,037 times, covering a total distance of 278 million miles. Optical observations indicated that at times the satellite stopped descending and that sometimes " humps " occurred in the orbit; no explanation has been offered for these phenomena.

Explorer 4

LAUNCHED BY: U.S.A.

LAUNCHING VEHICLE: U.S. Army 4-stage Jupiter C.

DATE: July 26, 1958.

LIFETIME: 15 months; down October 23, 1959.

SHAPE AND SIZE: Cylinder, 6 ft. 8 in. by 6.25 in. diameter.

WEIGHT:		
	Total:	38.4 lb.
	Equipment:	25.8 lb.

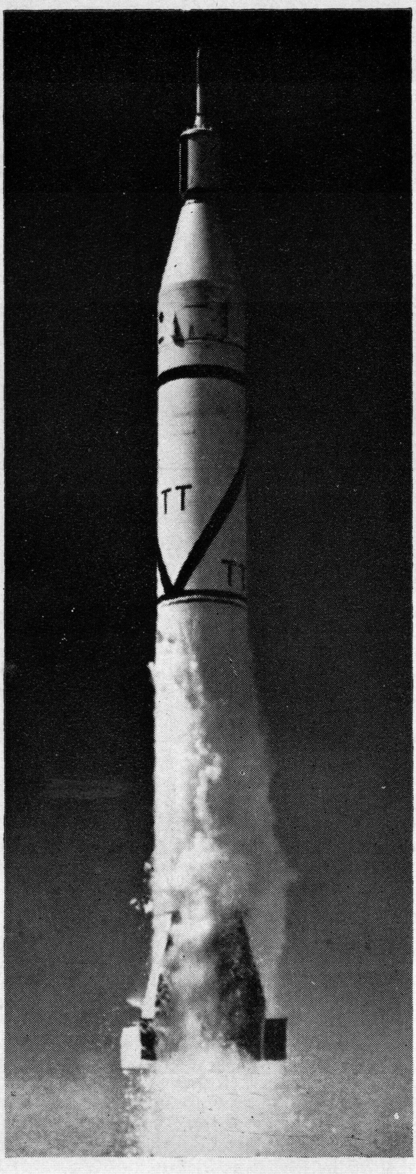
INITIAL ORBITAL HEIGHT: Apogee 1,380; Perigee 163 miles.

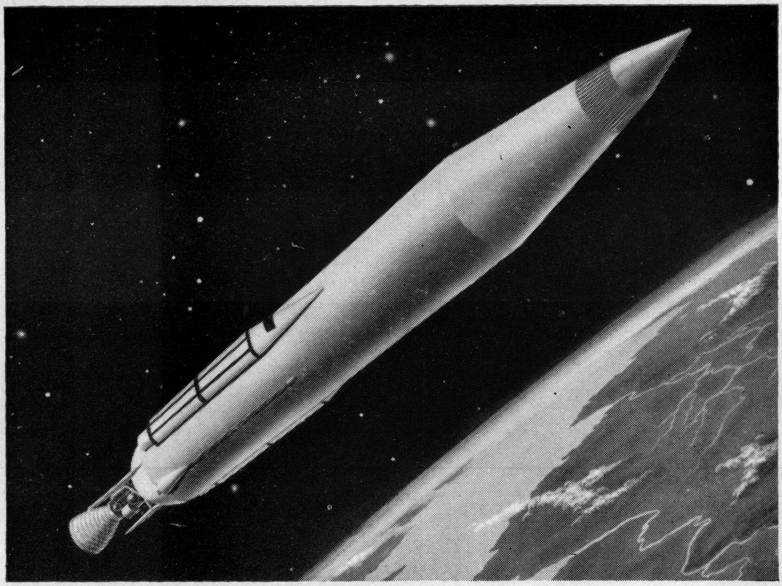
ORBITAL INCLINATION: 50° to Equator.

EXPERIMENTS: Measurement of corpuscular radiation at several intensity levels, using two Geiger-Mueller counters and two scintillation counters. Measurement of internal temperatures.

Remarks:

Specially instrumented to investigate the great radiation belt detected by Explorer 1. Data indicated that radiation doubles for every 60 miles over a threshold 250 miles beyond the Earth. Satellite detected that, close to Earth, radiation is weak near the geomagnetic equator and strongest near the magnetic poles. At 1,200 miles above South America, radiation intensity reached ten roentgens an hour—enough to give a space traveller his safe weekly dose in two minutes. One Geiger counter, covered in $\frac{1}{16}$ in. lead shield, recorded 60% as many impacts as an unshielded counter, indicating very high energy radiation.





Score Atlas

LAUNCHED BY: U.S.A.
LAUNCHING VEHICLE: U.S.A.F. WS-107A-1 Atlas 10B.
DATE: December 18, 1958. *LIFETIME:* One month; down January 21, 1959.
SHAPE AND SIZE: Cylindrical, 85 ft. by 10 ft. diameter.
WEIGHT: Total: 8,661 lb. approx.*
Equipment: 150 lb.
INITIAL ORBITAL HEIGHT: Apogee 928; Perigee 115 miles.
ORBITAL INCLINATION: 32° to Equator.
EXPERIMENTS: Orbital relay of tape-recorded messages.

* *This weight is approximate because it was impossible to determine accurately the weight of residual propellents which went into orbit. The maximum weight possible has been estimated at* 8,661 *lb.*

Remarks:

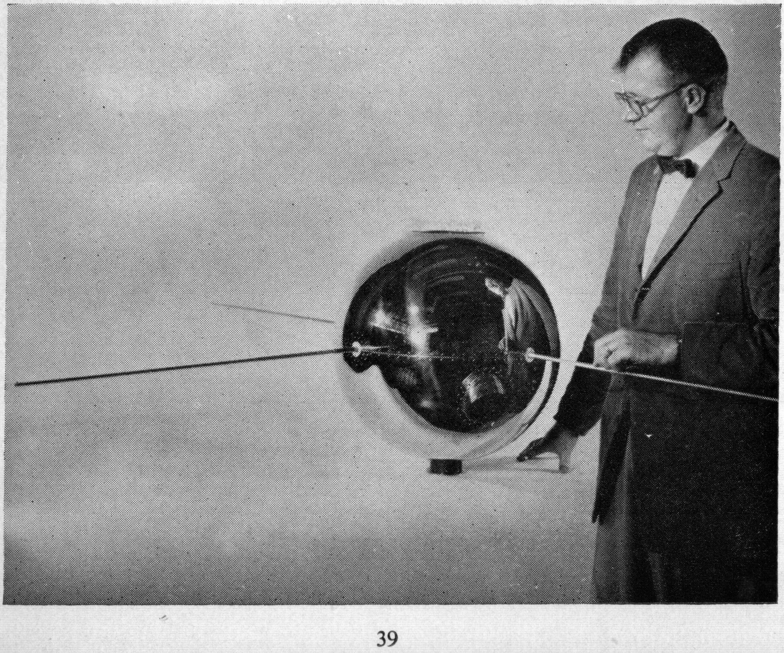
This satellite comprised an entire Atlas ICBM, approximating in size to two railway coaches placed end to end, and is designated U.S. Army Project SCORE (Signal Communications Orbit Relay Experiment). Messages were transmitted to the satellite, where they were recorded on tape for later transmission when commanded to do so by ground signals. Some success was achieved, including the receiving and transmission of a special Christmas message by President Eisenhower. This was the first time a human voice had been beamed from space. SCORE represented only a small introduction to the important field of communication satellites, which, with meteorological satellites, may provide one of the first practical uses of the new scientific field of astronautics.

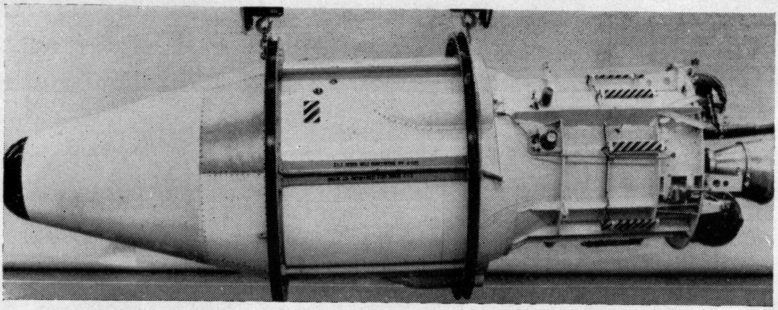
Vanguard 2

LAUNCHED BY: U.S.A.
LAUNCHING VEHICLE: U.S. Navy 3-stage TV-3.
DATE: February 17, 1959. *LIFETIME:* Over ten years.
SHAPE AND SIZE: Sphere, 20 in. diameter *WEIGHT:* 20.74 lb.
ORBITAL HEIGHT: Apogee 2,064; Perigee 347 miles.
ORBITAL INCLINATION: 33° to Equator.
EXPERIMENTS: Survey of Earth's cloud cover, using two infra-red photocells.

Remarks:

Prototype meteorological satellite. The two photocells produced electrical charges in proportion to the intensity of reflection from the Earth's clouds and terrain. Data was telemetered to the ground via a tape recorder. Solar cells operated a switch which stopped the tape when the satellite was in the shadow of the Earth, to conserve battery power. Tape was restarted by same means. The satellite was spun like a top to provide stability, but unfortunately it also developed a wobbling (precessing) motion which rendered the clear interpretation of data almost impossible. No worthwhile pictures were obtained.





Discoverer 1

LAUNCHED BY: U.S.A.
LAUNCHING VEHICLE: U.S.A.F. 2-stage Thor-Agena.
DATE: February 28, 1959. *LIFETIME:* Five days; down March 5, 1959.
SHAPE AND SIZE: Cylinder, 19 ft. by 5 ft. diameter.
WEIGHT: Total. 1,300 lb. Equipment: 245 lb.
INITIAL ORBITAL HEIGHT: Apogee 605; Perigee 99 miles.
ORBITAL INCLINATION: 3° off Earth's North-South axis.
EXPERIMENTS: Test of propulsion, guidance, staging and communications equipment.

Remarks:

First U.S. polar-orbit satellite, launched from Pacific Missile Range, Vandenberg Air Force Base, California. Radio transmitter apparently failed, only intermittent signals being received. Another theory is that the stabilising system failed, allowing the satellite to tumble end over end, making its directional radio signals difficult to receive. This satellite may not have achieved orbit.

Discoverer 2

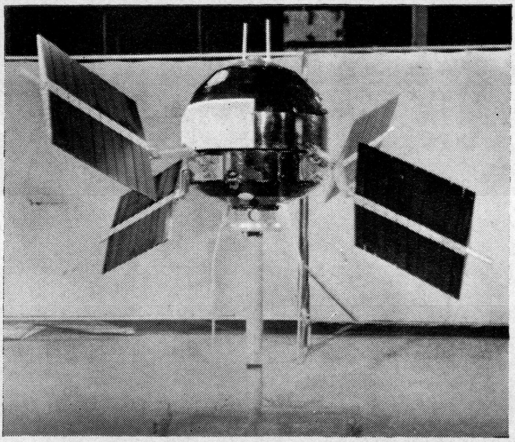
LAUNCHED BY: U.S.A.
LAUNCHING VEHICLE: U.S.A.F. 2-stage Thor-Agena.
DATE: April 13, 1959. *LIFETIME:* Two weeks; down April 26, 1959.
SHAPE AND SIZE: Cylinder, 19 ft. 2½ in. by 5 ft. diameter.
WEIGHT: Total: 1,610 lb. Equipment: 245 lb.
INITIAL ORBITAL HEIGHT: Apogee 220; Perigee 142 miles.
ORBITAL INCLINATION: 0.2° off Earth's North-South axis.
EXPERIMENTS: To recover capsule containing radiation emulsion packs.

Remarks:

Satellite contained a 195 lb. hemisphere-shaped pressurised capsule 27 in. long by 33 in. diameter. This was apparently ejected successfully on April 14, although at the wrong time. Calculation indicated a descent near the Spitzbergen archipelago, but despite an intensive search the capsule was never found.

The planned sequence of events was that, after ejection, a retro-rocket would fire, slowing the capsule and causing it to descend. At approximately 55,000 ft. a special parachute, lined with aluminium to assist radar tracking, would be streamed to lower the capsule gently. At the same time a recovery beacon would start to transmit. In the landing area, a fleet of eight C-119 Packet transport aircraft trailing 15 ft. by 30 ft. nylon harnesses would try to home on the beacon in an attempt to snag the capsule before it fell in the sea.

Explorer 6



LAUNCHED BY: U.S.A.
LAUNCHING VEHICLE: U.S.A.F. 3-stage Thor-Able.
DATE: August 7, 1959. *LIFETIME:* Over one year.
SHAPE AND SIZE: Spheroid, 26 in. diameter by 29 in. long, with four 18 in. square solar-celled vanes.
WEIGHT: 142 lb.
INITIAL ORBITAL HEIGHT: Apogee 26,383; Perigee 157 miles.
ORBITAL INCLINATION: 47° to Equator.
EXPERIMENTS: Measurement of three specific levels of radiation in Earth's radiation belt; investigation into behaviour of radio waves in ionosphere, mapping of Earth's magnetic field, detection of micrometeors, survey of Earth's cloud cover; all aimed at learning more about " deep space " equipment.

Remarks:

Nicknamed the " paddlewheel " satellite because of its four solar-energy electricity-generating vanes, this provided the first discernible picture from space of the Earth's cloud coverage. The picture covered a broad area of the central Pacific and was made from signals received on August 14, 1959. An extremely small video bandwidth, 1.5 cycles per second, was employed to transmit the picture, which took 40 minutes. This may be contrasted with the commercial TV bandwidth of about 4 million cycles per second, the picture time being 1/30 second.

The satellite spun at 2½ times per second, and once per revolution the camera unit recorded the light or dark impression in the form of an electrical impulse. The impulse was then reduced to a single dot; a row of dots formed a line and eventually formed the image. The pictures were crude, but just discernible.

The satellite ceased transmitting abruptly on October 6, much sooner than the year anticipated; this cessation was assumed due to meteoric damage.

NOTE: This U.S.A.F. Explorer 6 should not be confused with the U.S. Army Explorer 6 which, launched by a Juno 2 on July 16, 1959, suffered control failure immediately after take-off, and failed to orbit.

Discoverer 5

LAUNCHED BY: U.S.A.
LAUNCHING VEHICLE: U.S.A.F. 2-stage Thor-Agena.
DATE: August 13, 1959. *LIFETIME:* Six weeks; down September 28, 1959.
SHAPE AND SIZE: Cylinder, 19 ft. by 5 ft. diameter.
WEIGHT: Total: 1,700 lb.
Capsule: 300 lb.
INITIAL ORBITAL HEIGHT: Apogee 450; Perigee 136 miles.
ORBITAL INCLINATION: 80° to Equator.
EXPERIMENTS: Ejection and recovery of capsule from orbit.

Remarks:

Satellite carried special guidance controls to ensure stabilisation in a horizontal position during its polar orbit. While in orbit, all instrumentation worked as intended. Re-entry capsule was scheduled to be ejected automatically after the 17th revolution. Aircraft and ships were positioned in the Hawaiian Islands area but, although ejection was effected, the capsule was not recovered.

An unidentified satellite detected in the Spring of 1960 is now thought to be this capsule, in an orbit with an apogee 500 miles higher than that achieved by the parent satellite body. This indicates that the capsule was not aligned correctly when the retro-rockets were fired.

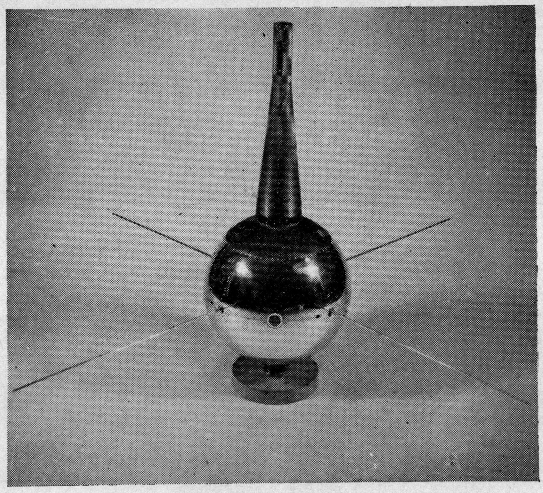
Discoverer 6

LAUNCHED BY: U.S.A.
LAUNCHING VEHICLE: U.S.A.F. 2-stage Thor-Agena.
DATE: August 19, 1959. *LIFETIME:* Two months; down October 20, 1959.
SHAPE AND SIZE: Cylindrical, 19 ft. long by 5 ft. diameter.
WEIGHT: Total: 1,700 lb.
Capsule: 300 lb.
INITIAL ORBITAL HEIGHT: Apogee 537; Perigee 139 miles.
ORBITAL INCLINATION: 84° to Equator.
EXPERIMENTS: Ejection and recovery of capsule from orbit.

Remarks:

Satellite carried special guidance controls to ensure stabilisation in a horizontal position during its polar orbit. While in orbit all instrumentation worked as intended. Re-entry capsule was programmed to be ejected automatically after the 17th revolution. Aircraft and ships were positioned in the Hawaiian Islands area but, although ejection was effected, the capsule was not recovered. It is assumed that malfunction occurred after ejection.

Vanguard 3



LAUNCHED BY: U.S.A.
LAUNCHING VEHICLE: U.S. Navy 3-stage TV-3.
DATE: September 18, 1959. *LIFETIME:* 40 years (estimated).
SHAPE AND SIZE: 20 in. sphere from which 26 in. tapered tube extends.
WEIGHT: Total: 100 lb. approx.
Instruments: 50 lb.
INITIAL ORBITAL HEIGHT: Apogee 2,329; Perigee 319 miles.
ORBITAL INCLINATION: 33° to Equator.
EXPERIMENTS: Measurement of Earth's magnetic field, X-rays from the Sun and environmental conditions in space.

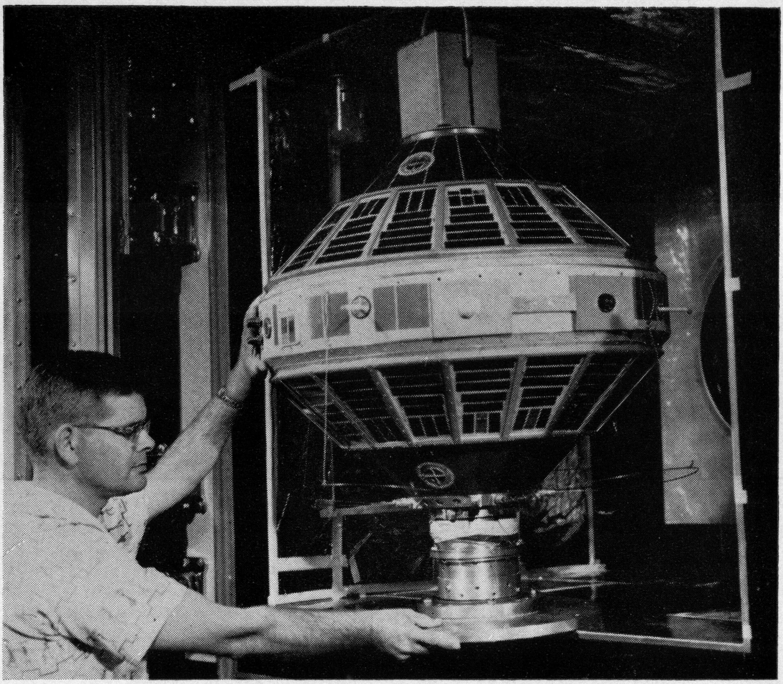
Remarks:

The three experiments in this satellite, the last in the Vanguard series, provided the greatest variety of studies in any single U.S. satellite to date. Earth's magnetic field measurement helped to chart this field and provided information indicating the best routes for manned space flight, to avoid regions of intense radiation trapped in the field.

The X-ray experiment was to find out the effect of the Sun's radiation on the Earth's atmosphere.

The environmental temperature, and erosion through bombardment by dust, micrometeorites, ions and molecules, provided data on conditions in space which will be of value to the design of future satellites and manned spacecraft.

Data was successfully transmitted over a period of 85 days, almost the expected life (90 days) of the batteries.



Explorer 7

LAUNCHED BY: U.S.A. *LAUNCHING VEHICLE:* 4-stage Juno 2.
DATE: October 13, 1959. *LIFETIME:* 20 years.
SHAPE AND SIZE: Double-cone, 30 in. long by 30 in. diameter.
WEIGHT: 91.5 lb.
INITIAL ORBITAL HEIGHT: Apogee 678; Perigee 345 miles.
ORBITAL INCLINATION: 50° to Equator.
EXPERIMENTS: Chemical identification and count of heavy particles of cosmic rays; measurement of radiation balance and micrometeorites.

Remarks:

Known technically as the composite radiation satellite, this was one of the more successful U.S. vehicles and the last of the satellites planned as part of the International Geophysical Year programme.

The radiation balance experiment—study of the transfer of heat from the tropics to polar regions and from Earth back into space—is the thermal radiation ' budget ' which is thought to have a great influence on the Earth's weather.

The cosmic ray experiment is providing data of use in manned space flight.

To prevent the satellite's solar-powered transmitters from cluttering up the wavebands after their usefulness has ceased, a timer is installed to switch off the radio after one year.

Discoverer 7

LAUNCHED BY: U.S.A.
LAUNCHING VEHICLE: U.S.A.F. 2-stage Thor-Agena.
DATE: November 7, 1959. *LIFETIME:* 19 days; down November 26, 1959.
SHAPE AND SIZE: Cylindrical, 19 ft. 2½ in. long by 5 ft. diameter.
WEIGHT: Total: 1,700 lb.
Capsule: 300 lb.
INITIAL ORBITAL HEIGHT: Apogee 524; Perigee 100 miles.
ORBITAL INCLINATION: 82° to Equator.
EXPERIMENTS: Launching technique, propulsion, communications, orbita performance and ejection and recovery of capsule from orbit.

Remarks:

Re-entry vehicle protected by a heat shield of the ablating type, in which the heat generated by air friction during re-entry is dissipated by melting and vapourising the material on the surface of the heat shield (a method proved on Thor and Atlas missiles).

Recovery system was designed to function in an air or water environment for ten hours after ejection from orbit.

During previous Discoverer flights, the internal temperature of the satellites had dropped well below the 70° design level of the batteries, thereby reducing battery life. To overcome the unexpected low temperatures, the internal compartment was heated and battery capacity was doubled.

The capsule was not, however, recovered.

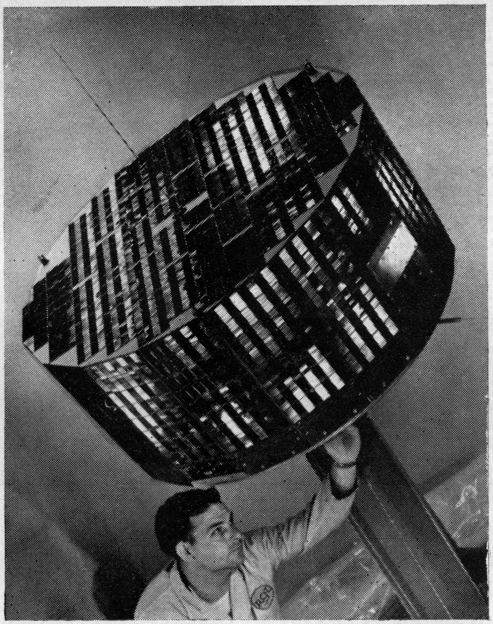
Discoverer 8

LAUNCHED BY: U.S.A.
LAUNCHING VEHICLE: U.S.A.F. 2-stage Thor-Agena.
DATE: November 20, 1959. *LIFETIME:* Four months; down March 8, 1960.
SHAPE AND SIZE: Cylindrical, 19 ft. 2½ in. long by 5 ft. diameter.
Capsule: 27 in. long by 33 in. wide.
WEIGHT: Total: 1,700 lb.
Capsule: 300 lb.
INITIAL ORBITAL HEIGHT: Apogee 1,042; Perigee 115 miles.
ORBITAL INCLINATION: 81° to Equator.
EXPERIMENTS: Launching technique, propulsion, communications, orbital performance and ejection and recovery of capsule from orbit.

Remarks:

Like previous Discoverer satellites, this was due to make 17 orbits before capsule ejection. The point of re-entry was intended for an area 50 miles by 200 miles near Hawaii, where aircraft with nets would be patrolling and recovery ships waiting.

The capsule was not recovered.



Tiros I

LAUNCHED BY: U.S.A.

LAUNCHING VEHICLE: 3-stage Thor-Able.

DATE: April 1, 1960.

LIFETIME: 50-100 years.

SHAPE AND SIZE: Drum, 42 in. diameter by 19 in. long.

WEIGHT: 270 lb.

INITIAL ORBITAL HEIGHT: Apogee 466; Perigee 429 miles.

ORBITAL INCLINATION: 48° to Equator.

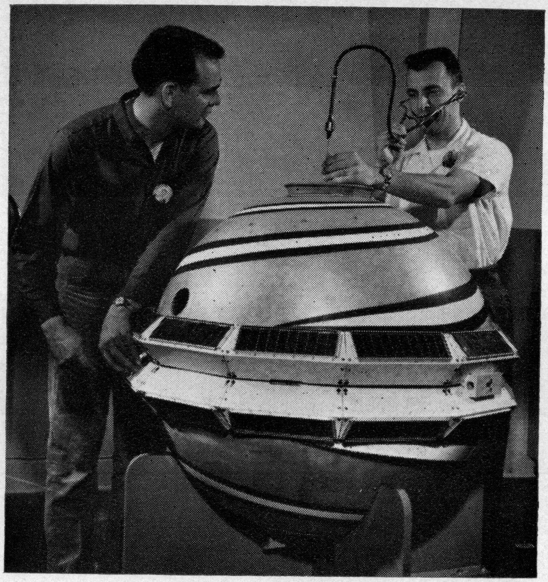
EXPERIMENTS: Test of experimental television techniques for recording and transmission of Earth's cloud coverage.

Remarks:

With a name standing for Television and Infra-Red Observation Satellite, this is one of the more successful U.S. devices orbited up to this time. Although not equipped with infra-red radiation sensors, its two vidicon television cameras worked exceptionally well and provided the first of the cloud cover pictures which promise in time to revolutionise meteorological forecasting. The two cameras, identical except for their lenses, consist of two parts: a $\frac{1}{2}$ in. vidicon tube and a focal plane shutter which permits still pictures to be stored on the tube screen. An electron beam converts this stored picture into a TV-type electronic signal which can be transmitted to ground receivers. One camera incorporated a wide-angle lens, and took pictures covering an 800-mile square; the other had a narrow-angle lens covering an 80-mile square area in greater detail. Out of ground station range the satellite recorded up to 32 photographs on storage tape for later relay when interrogated. This permitted pictures to be taken on the other side of the world and then transmitted to stations in the United States.

An important part of the research programme is an attempt to relate photographic observations to measurements of the heat balance data obtained by the Explorer 7 satellite. Tiros was an experimental device and not an operational system. When the batteries failed after 78 days, over 22,000 photographs had been relayed.

Transit 1-B



LAUNCHED BY: U.S.A.
LAUNCHING VEHICLE: U.S.A.F. 2-stage Thor-AbleStar.
DATE: April 13, 1960. LIFETIME: 16 months.
SHAPE AND SIZE: Sphere, 36 in. diameter.
WEIGHT: 265 lb.
INITIAL ORBITAL HEIGHT: Apogee 479; Perigee 233 miles.
ORBITAL INCLINATION: 51° to Equator.
EXPERIMENTS: None: equipment includes four transmitters broadcasting on four frequencies from a broad-band antenna in the form of a spiral stripe round the exterior.

Remarks:

Experimental U.S. Navy satellite, intended to provide data for a future navigation satellite system based upon initial study of signals received from Russian *Sputnik* 1 satellite. Through Doppler effect the signals from a satellite increase in frequency as it moves nearer to a receiver on Earth, and diminish as it recedes. By measuring the rate of change of these frequencies the exact distance from the satellite can be calculated. The position of the satellite can be computed accurately, thereby enabling the position of the ground receiver to be determined.

The developed system should give the U.S. an all-weather navigational aid of unrivalled accuracy. It has a special application for missile-firing submarines, to which navigational accuracy is particularly important.

Commercial shipping is not likely to make great use of the Transit system, as existing methods are adequate, but any ship so wishing may use the facilities by installing a whip aerial and a relatively inexpensive receiver-computer.

The U.S. Navy plans to have four Transit satellites orbiting by 1962.

Discoverer 11

LAUNCHED BY: U.S.A.
LAUNCHING VEHICLE: U.S.A.F. Thor-Agena.
DATE: April 15, 1960. *LIFETIME:* 11 days; down April 26, 1960.
SHAPE AND SIZE: Cylindrical, 19 ft. long by 5 ft. diameter.
WEIGHT: Total: 1,700 lb.
Capsule: 300 lb.
INITIAL ORBITAL HEIGHT: Apogee 380; Perigee 109 miles.
ORBITAL INCLINATION: 80° to Equator.
EXPERIMENTS: Ejection and recovery of capsule from orbit; special tracking experiment as part of Transit development programme.

Remarks:

Ejection apparently successful, but capsule not recovered. Although the ' primary ' objective was again not realised, much subsidiary experience was gathered and reliability achieved with this and previous Discoverers. For example, the complex guidance system, which scans the horizon with infra-red sensors and utilises gas jets to keep the satellite's body parallel with the ground throughout its orbit, is being adopted on the Ranger project for soft-landing an instrumented probe on the Moon.

NOTE: Discoverers 9 *and* 10, *launched on February* 4 *and* 19 *respectively, failed to achieve orbit. Discoverer* 9 *failed due to ground equipment malfunction; the tower which moves the fuelling equipment from the vehicle damaged its second stage, causing premature shut-down of the first stage. Discoverer* 10 *was destroyed by the Range Safety Officer when it veered off course at* 20,000 *ft.*

Sputnik 4 (Spaceship 1)

LAUNCHED BY: U.S.S.R. *LAUNCHING VEHICLE:* Not known.
DATE: May 15, 1960. *LIFETIME:* Two to four years.
SHAPE AND SIZE: Cylindrical. *WEIGHT:* Total: 10,008 lb.
Cabin: 5,512 lb.
INITIAL ORBITAL HEIGHT: Apogee 230; Perigee 195 miles.
ORBIT AFTER FIRING RETRO-ROCKET ON MAY 19*:* Apogee 429; Perigee 191 miles.
ORBITAL INCLINATION: 65° to the Equator.
EXPERIMENTS: Attempted recovery of cabin intended for manned space flight.

Remarks:

Although initial Russian statements indicated that it was not intended to try and retrieve the cabin of *Sputnik* 4 from orbit, later announcements seemed to contradict this. Retro-rockets were fired " to deflect the ship down from orbit and detach its pressurized cabin ". Separation occurred, but owing to a fault in the orientation system the retro-rockets, instead of reducing the speed of the cabin, increased it slightly, pushing it into a new elliptical orbit with a much higher apogee of over 400 miles.

While the three main parts of the spaceship vehicle were orbiting, the brightest was the rocket carrier, second brightest was the instrument section, and lastly the ejected cabin. Three transmitters in the cabin made it easy to track and it was often observed visually.

The pressurised cabin carried a load equivalent to the weight of a man and all the equipment necessary for manned space flight.

The weight of the cabin instrumentation, power supply, solar converters and chemical batteries was given as 3,250 lb.

Midas 2

LAUNCHED BY: U.S.A.
LAUNCHING VEHICLE: U.S.A.F. 2-stage Atlas-Agena A.
DATE: May 24, 1960. *LIFETIME:* 40 months (estimated).
SHAPE AND SIZE: Cylindrical, 22 ft. long by 5 ft. diameter.
WEIGHT: Total: 5,000 lb.
Instruments: 3,600 lb.
INITIAL ORBITAL HEIGHT: Apogee 322; Perigee 292 miles.
ORBITAL INCLINATION: 33° to Equator.
EXPERIMENTS: Infra-red, telemetry and communications equipment for overall test of system for detection of enemy missile launchings.

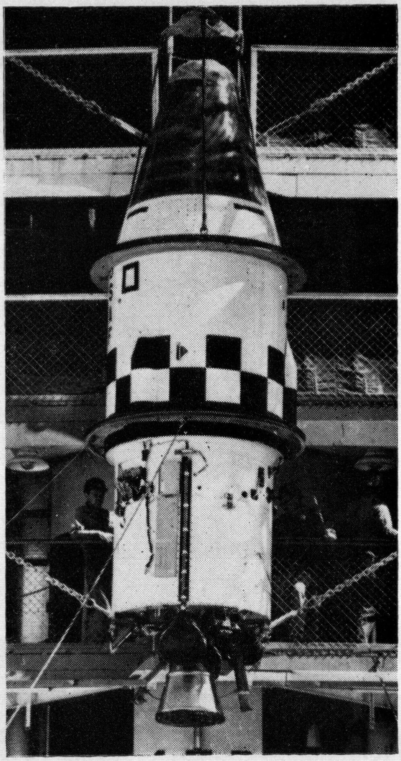
Remarks:

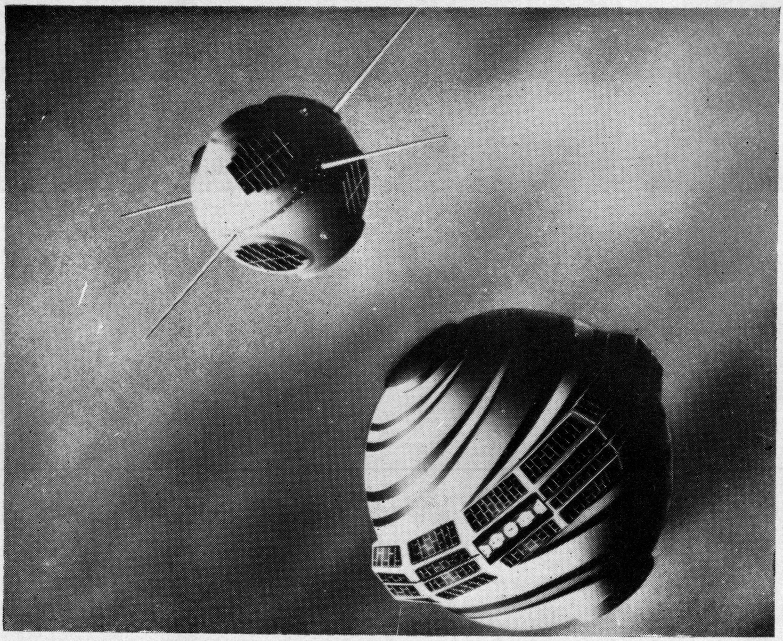
First satellite intended openly to fulfil a military function. Midas 2 was the first of a number of satellites designed to detect enemy missile launchings; hence the code name Midas—Missile Defence Alarm System.

Such a system encounters many problems of a fundamental nature; it must be able to differentiate between a missile taking off and a civil jet airliner taking off, or a large building on fire. Millions of square miles of territory will have to be surveyed, so that no position is unwatched for more than five minutes, the burning time of an ICBM.

The day after launch all appeared well and tests were about to begin by checking its response to large flares lit at Vandenberg and Edwards Air Force Bases, and perhaps to actual missile launchings. Next day, however, a fault developed in the data link telemetry transmitting infra-red scanner information, thereby ending the main experiment.

NOTE: *Midas* 1, *launched on February* 25, *was rendered abortive by faulty stage-separation.*





Transit 2-A (and N.R.L.)

LAUNCHED BY: U.S.A. *LAUNCHING VEHICLE:* Thor-AbleStar.
DATE: June 22, 1960. *LIFETIME:* 50 years (estimated).
SHAPE AND SIZE: Transit: Sphere, 36 in. diameter.
N.R.L.: Sphere, 20 in. diameter.
WEIGHT: Transit: 223 lb. N.R.L.: 42 lb.
INITIAL ORBITAL HEIGHT: Apogee 657; Perigee 382 miles.
ORBITAL INCLINATION: 33° to Equator.
EXPERIMENTS: Transit: Navigational tests and study of background cosmic noise. N.R.L.: Study of solar ultra-violet and X-rays.

Remarks:

This event introduced a new stage in the science of astronautics, for the launching vehicle orbited two quite different satellites at once. At the desired height they separated and went into individual orbits.

Main payload was Transit 2-A, representing the second significant step towards perfecting the U.S. Navy's all-weather navigation system. Although the satellite lacked parts to be incorporated in production versions, one tracking vessel has used its signals to fix its position to within a quarter of a mile.

Stowed inside this satellite is a Canadian instrument for studying cosmic noise. When this experiment is completed, weights will be released to stop the satellite from spinning, which should increase further its accuracy as a navigational aid.

Second payload is a satellite left over from the Vanguard programme. Given a " free lift " into space by Transit, this is now sending back useful information to increase our knowledge of radio blackouts and of some kinds of weather.

Discoverer 13

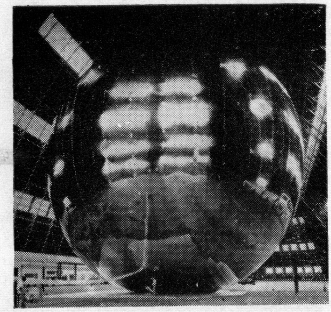
LAUNCHED BY: U.S.A. *LAUNCHING VEHICLE:* U.S.A.F. Thor-Agena.
DATE: August 10, 1960. *LIFETIME:* Three months (estimated).
SHAPE AND SIZE: Cylindrical, 19 ft. 2 in. long by 5 ft. diameter.
Capsule: 27 in. long by 33 in. diameter.
WEIGHT: Total: 1,700 lb. Capsule: 300 lb.
INITIAL ORBITAL HEIGHT: Apogee 436; Perigee 161 miles.
ORBITAL INCLINATION: 83° to Equator.
EXPERIMENTS: Propulsion, communications, orbital performance, advanced engineering tests, ejection and recovery of capsule from orbit.

Remarks:

Instrumented capsule successfully recovered after satellite had completed 16 orbits, thus giving the U.S.A. a major " first " in the satellite field. Similar to previous Discoverers, except that stabilising rockets were replaced by gas jets, as malfunction of rockets had been advanced as the reason for some of the previous failures.

Ejection signal beamed from Kodiak, Alaska, triggered off sequence of 22 events. First tipped nose of satellite down until it pointed to the Earth at 60°; pins released the capsule, which was then rotated by the gas jets to 60 r.p.m.; retro-rocket then fired to start descent. As capsule entered atmosphere, spinning ceased and gas jets, retro-rocket and remains of protective nose cone jettisoned. At 50,000 ft. the parachute opened, radio beacon started operating and aluminium " window " released to assist tracking. Capsule descended safely into sea about 330 miles from Honolulu, within target area of 60 miles × 200 miles. An attempt by C-119 Packets to snare the capsule in mid-air failed, and final recovery from sea was effected by a helicopter dispatched from the *Haiti Victory*.

Echo 1



LAUNCHED BY: U.S.A.
LAUNCHING VEHICLE: Thor Delta.
DATE: August 12, 1960.
LIFETIME: Over eight months.
SHAPE AND SIZE: Sphere, 100 ft.
WEIGHT: 132 lb.
INITIAL ORBITAL HEIGHT: Apogee 1,049; Perigee 945 miles.
ORBITAL INCLINATION: 47° to Equator.
EXPERIMENT: Orbital relay of radio messages.

Remarks:

Far larger than any previous satellite, Echo 1 was a sphere made of transparent plastic material 0.0196 in. thick, coated with a thin film of aluminium 0.0005 in. thick to make it an excellent reflector for electro-magnetic radiation. The sphere, launched folded, was inflated in space by 30 lb. of sublimating powder that expanded into gas when exposed to the rays of the Sun.

First message relayed by this passive communications satellite was " This is President Eisenhower speaking " which was transmitted from Goldstone, California, to Holmdel, New Jersey, 2,500 miles away. Later experiments included the transmission of teletype signals, facsimile photographs, two-way telephone conversations using commercial equipment, transcontinental and transatlantic signal relays and experiments to determine the effects of the ionosphere on radio signals.

Scientists hope that such satellites will provide a new system of intercontinental communications unaffected either by the curvature of the Earth's surface, or by atmospheric disturbances. A " string " of them should be capable of handling 1,000 intercontinental telephone, radio and television signals simultaneously. Together with the meteorological satellites, communications satellites promise to be among the first to provide practical benefit and, possibly, financial return.

Discoverer 14

LAUNCHED BY: U.S.A. *LAUNCHING VEHICLE:* U.S.A.F. Thor-Agena-A.
DATE: August 18, 1960. *LIFETIME:* Not known
SHAPE AND SIZE: Cylindrical, 19 ft. 2 in. long by 5 ft. diameter.
WEIGHT: Total: 1,700 lb. Recovered capsule: 85 lb.
INITIAL ORBITAL HEIGHT: Apogee 502; Perigee 116 miles.
ORBITAL INCLINATION: Approximately 80° to Equator.
EXPERIMENTS: Propulsion, communication, orbital performance, advanced engineering tests, ejection and recovery of capsule from orbit.

Remarks:

Re-entry initiated on satellite's 17th orbit. At a height of 8,000 ft., about 300 miles north-west of Hawaii, the re-entry capsule was successfully " snatched " in the air, as it descended, by a trapeze-like framework towed behind a C-119.

Sputnik 5 (Spaceship 2)

LAUNCHED BY: U.S.S.R. *LAUNCHING VEHICLE:* Not known.
DATE: August 19, 1960. *LIFETIME:* 27 hours.
SHAPE AND SIZE: Cylindrical. *WEIGHT:* Total: 10,140 lb.
INITIAL ORBITAL HEIGHT: Apogee 212; Perigee 191 miles.
ORBITAL INCLINATION: 65° to Equator.
EXPERIMENTS: Measurement of primary cosmic radiation and ultra-violet radiation from Sun. Test in orbit of spaceship intended for manned space flight, and recovery of ship from orbit. (*Photograph on page 10*).

Remarks:

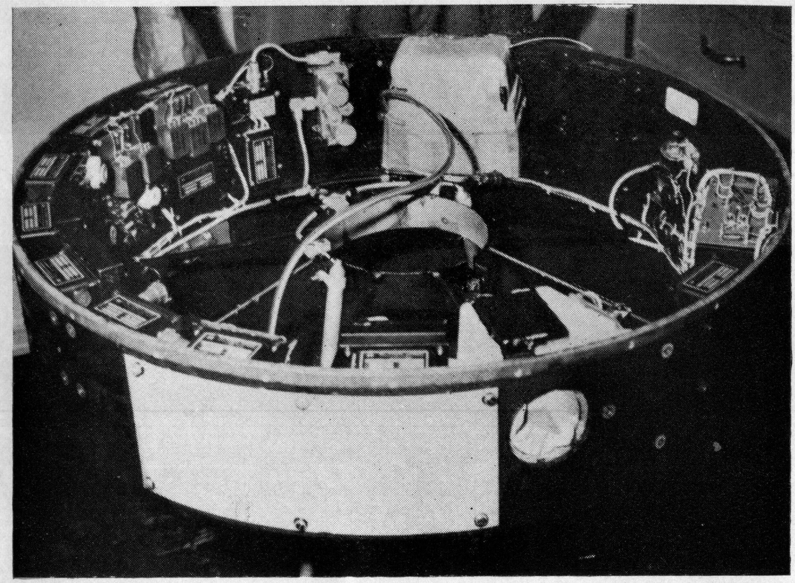
Apparently similar to the large vehicle launched in May, this satellite was successfully recovered from orbit on its 18th revolution some 27 hours after launching. Within the cabin were two mongrel dogs, *Belka* (Squirrel) and *Strelka* (Arrow), together with 40 mice, two rats, a number of flies, microbes, plants, fungi, and seeds of maize, wheat, peas, onions and nigella. Scientific equipment included blocks of thick nuclear photographic emulsions weighing about 130 lb. While in orbit, the reactions of the dogs were studied by television cameras in the cabin and at one stage pictures were obtained of one dog eating.

The rats, mice and flies were chosen because they breed quickly, thus allowing scientists to check comparatively rapidly the effects of radiation received in orbit, over a period of several generations.

When the space ship was at a low altitude a capsule containing the two dogs and other more important flora and fauna was ejected. This was done to ensure a safe landing for these, but in the event the spaceship itself also landed without any damage. The dogs and other animals were alive and well at the time this book went to press.

Announcing the landing, the Russians claimed that the deviation from the programmed impact point (not given) was just over six miles; this is a remarkable achievement and provides further evidence of the precise control mechanisms available to Soviet astronauts.

SPACE PROBES



Pioneer I

LAUNCHED BY: U.S.A. *DATE:* October 11, 1958.
LAUNCHING VEHICLE: 3-stage U.S.A.F. Thor-Able 1.
WEIGHT: Total: 83.8 lb. Instruments: 39 lb.
SHAPE AND SIZE: Double-ended cone; 29 in. diameter by 30 in. long.
ORBITAL DATA: Maximum distance reached: 70,700 miles.
EXPERIMENTS: Measurement of magnetic fields of Earth and Moon; of density of meteoric matter in flight path; of temperature and cosmic radiation. Special photo-electric camera installed to scan lunar surface.

Remarks:

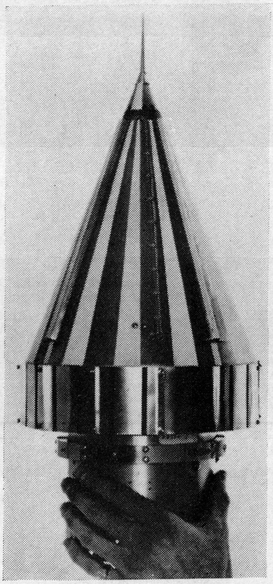
Although a failure, in that it did not reach the close vicinity of the Moon as planned, Pioneer 1 reached a height considered sufficiently great for it to be listed here as the first of the " deep-space " probes. With it was made the first serious attempt to break free of the Earth's gravitational forces.

The required velocity was 24,034 m.p.h.; but because the probe travelled 3.5° above the planned trajectory the velocity attained was only 23,454 m.p.h. In an attempt to gain the extra speed, the eight vernier rockets in the fourth stage were fired, but this increased the speed by only 109 m.p.h. Falling back to Earth, the probe is assumed to have disintegrated in the upper atmosphere over the South Pacific at 10.46 p.m. on October 12, 1958.

Much valuable data was telemetered during the brief flight, a lot of it from regions not previously explored by satellites.

NOTE: Pioneer 2 *fell back after reaching only* 970 *miles, when the third stage failed to ignite.*

Pioneer 3



LAUNCHED BY: U.S.A.
LAUNCHING VEHICLE: 4-stage U.S. Army Juno 2.
DATE: December 6, 1958.
WEIGHT: 12.95 lb.
SHAPE AND SIZE: Cone, 23 in. long by 10 in. diameter.
ORBITAL DATA: Maximum distance reached: 63,600 miles.
EXPERIMENTS: Measurement of radiation in space; testing devices for future probes; photo-electric sensor for triggering cameras on future Moon probe.

Remarks:

Failed in primary objective of reaching Moon, through first stage motor cutting 3.7 seconds early, resulting in insufficient velocity. (Design velocity, 24,486 m.p.h.; velocity attained, 23,606 m.p.h.)

As the probe did not approach the Moon, many of the instruments were not activated. However, the 38-hour flight showed there are two great radiation belts surrounding the Earth: the first roughly between 1,400 and 3,400 miles from the Earth's surface; the second between 8,000 and 12,000 miles.

Probe re-entered the atmosphere over French Equatorial Africa and disintegrated at 2.51 p.m., December 7, 1958.

Lunik 1

LAUNCHED BY: U.S.S.R.
DATE: January 2, 1959.
LAUNCHING VEHICLE: Modified Soviet ICBM?
WEIGHT. 796.5 lb.
SHAPE AND SIZE: Sphere, approx. 33 in. diameter.
ORBITAL DATA: In orbit round Sun. Aphelion 122 million miles; Perihelion 91 million miles. Period 450 days. Average speed in orbit 63,100 m.p.h.
EXPERIMENTS: Measurement of internal and external temperatures; of gas components of interplanetary matter and corpuscular radiation of the Sun. Measurement of magnetic fields of the Earth and Moon, micrometeors, heavy nuclei in primary cosmic rays. Four radio transmitters installed.

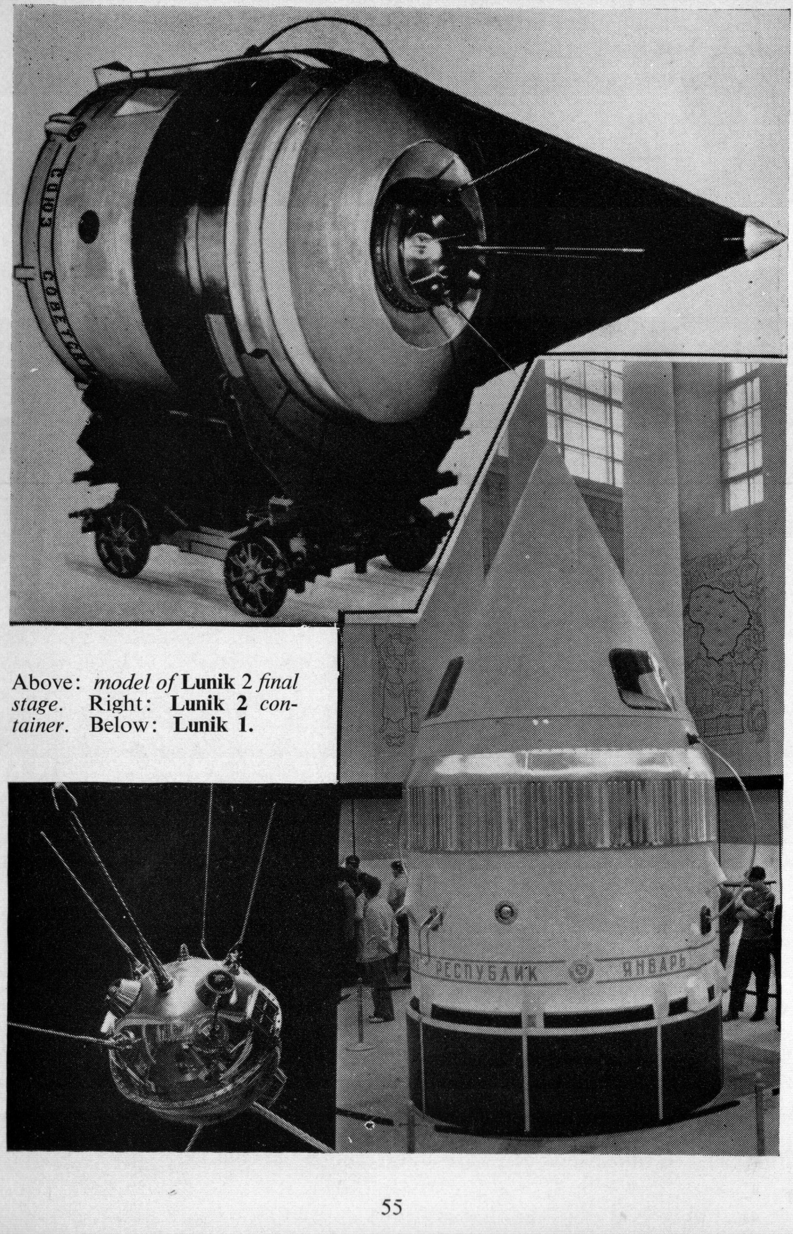
Remarks:

Sometimes known as *Mechta*, or Planet 10*, this probe was the greatest step forward in astronautics since the launching of the first artificial satellite. For the first time a man-made object was projected beyond the practicable influence of the Earth's gravity, and into orbit round the Sun, as the first artificial planet.

When well on its journey a timing device released sodium vapour. This dispersed in space and glowed brightly in the sunlight, so assisting Soviet tracking stations to obtain an accurate visual fix.

The probe passed within an estimated 4,600 miles of the Moon. This indicates very accurate and reliable guidance equipment; but the presence on board the probe of metal discs and pennants bearing the U.S.S.R. crest implies that a direct hit was probably hoped for.

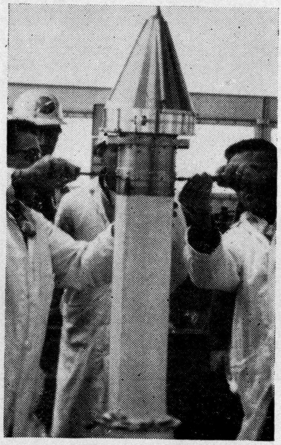
* *There are nine natural planets, of which the Earth is one.*


СОЮЗ СОВЕТСК
РЕСПУБЛИК
ЯНВАРЬ

Above: *model of* **Lunik** 2 *final stage.* Right: **Lunik 2** *container.* Below: **Lunik 1.**

Pioneer 4

LAUNCHED BY: U.S.A. *LAUNCHING VEHICLE:* U.S. Army 4-stage Juno 2. *DATE:* March 3, 1959. *WEIGHT:* 13.4 lb. *SHAPE AND SIZE:* Cone, 20 in. long by 9 in. diameter.



ORBITAL DATA: In orbit round the Sun. Aphelion 108 million miles; Perihelion 92 million miles. Period: 406 days. Average speed in orbit, 65,144 m.p.h.

Distance outside average Earth orbit at aphelion —14,995,000 miles. Distance inside average Earth orbit at perihelion—1,236,000 miles.

EXPERIMENTS: Measurement of radiation belts; detection and measurement of energetic solar gas; cosmic ray intensity beyond Earth's magnetic field and Moon's magnetic field. Photo-electric sensor installed.

Remarks:

Probe not completely successful owing to trajectory flight path being 4.5° lower than intended; maximum velocity of 24,789 m.p.h. was 196 m.p.h. below that desired.

Closest distance to Moon, 37,300 miles (not near enough to activate the photo-sensor).

Contact with probe retained up to 407,000 miles from Earth, the maximum distance achieved up to that time.

Two Geiger tubes measured radiation, one bare, the second wrapped in sheet lead. Comparison between readings will provide data on the shielding required for manned interplanetary travel.

Lunik 2

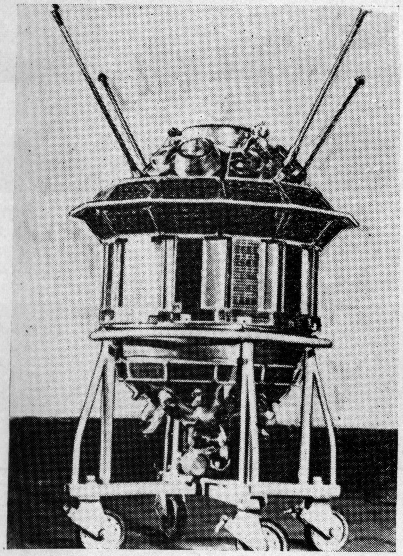
LAUNCHED BY: U.S.S.R. *LAUNCHING VEHICLE:* Not known.
DATE: September 12, 1959. *WEIGHT:* 858.4 lb.
ORBITAL DATA: Impacted Moon at 10.02 p.m. on September 14, 1959. Time for journey: 34 hours.
EXPERIMENTS: Measurement of Earth's and Moon's magnetic field; of radiation belts around the Earth and in the vicinity of the Moon; of X-rays and gamma rays; cosmic radiation and distribution of micrometeorites.

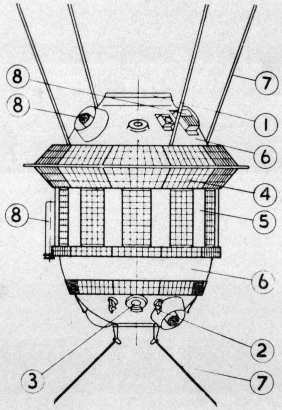
Remarks:

Made the first-ever physical contact with another body in the solar system.

The probe hit the Moon in the area of the Sea of Tranquility, the Sea of Serenity and the Sea of Vapours, about 500 miles north of the centre of the visible disc. Various astronomers have reported seeing dust clouds at the moment of impact, but none of these claims has been officially recognised. The probe carried commemorative emblems and metal pennants, like those of *Lunik* 1, which were scattered over the Moon's surface when it disintegrated on landing. An exceedingly precise guidance system must have been used to ensure the probe's accurate trajectory over a distance of more than a quarter of a million miles. To permit visual checking of the trajectory, a sodium cloud was emitted during the journey.

No magnetic field (within the limits of the equipment carried) was detected near the Moon; nor was any radiation belt apparent. Other measurements indicated that the Moon may have an exceedingly tenuous ionosphere.





(1) *Camera aperture;* (2) *orientation mechanism;* (3) *solar transducer;* (4) *solar batteries;* (5) *heat regulating grilles;* (6) *heat shields;* (7) *aerials;* (8) *instruments.*

Lunik 3

LAUNCHED BY: U.S.S.R. *LAUNCHING VEHICLE:* Not known.
DATE: October 4, 1959. *LIFETIME:* Six months, down in April 1960.
SHAPE AND SIZE: Cylindrical, 4 ft. diameter by 4 ft. 3 in. long.
WEIGHT: 614 lb.
ORBITAL DATA: Apogee 298,000 miles; Perigee 29,500 miles. Period, about 15 days.
EXPERIMENTS: Photographing of rear face of the Moon; determination of shape and distribution of mass of Moon.

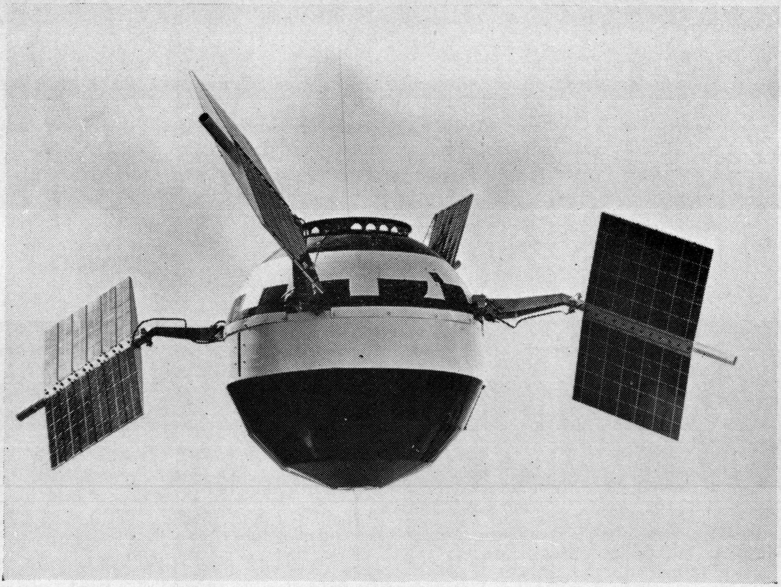
Remarks:

Sent back first photographs of the rear face of the Moon, which is not visible from the Earth.

Photographing process initiated by radio command signal from Earth when the probe was about 40,000 miles above the surface of the Moon. Exposures varied from frame to frame to ensure negatives of good contrast. After exposure, the film was fed into an automatic processing device, specially designed to work under conditions of weightlessness and wide temperature variations, where it was developed and fixed. After treatment the film was dried and passed into a special case ready for the transmission of the pictures—a great technical achievement in its own right. Pictures were televised while the probe was 70,000 miles beyond the Moon, or nearly 300,000 miles from the Earth.

Provision was made for re-running the films when the probe approached the Earth, but unfortunately transmission ceased during the return journey, presumably due to meteor damage.

NOTE: Although included in the list of deep-space probes, Lunik 3 can equally be considered an ordinary satellite which had a very extended elliptical orbit.



Pioneer 5

LAUNCHED BY: U.S.A. *LAUNCHING VEHICLE:* 3-stage Thor-Able 4.
DATE: March 11, 1960. *LIFETIME:* 100,000 years (estimated).
SHAPE AND SIZE: Spheroid, 26 in. diameter, with four 18 in. by 14 in. solar-celled vanes.
WEIGHT: Total: 94.8 lb.
Instruments: 40 lb.
ORBITAL DATA: In orbit round the Sun. Aphelion 92 million miles; Perihelion 75 million miles. Period 312 days.
EXPERIMENTS: Long distance radio communication, investigation of interplanetary space between the orbits of Earth and Venus; study of methods for measuring astronautical distances.

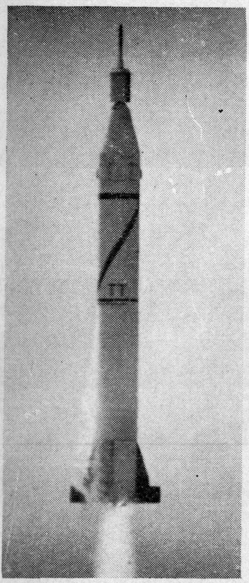
Remarks:

First probe to investigate *inside* the Earth's orbit.

Slight imperfections in guidance caused the probe not quite to meet its hoped-for aim of passing close to Venus. Closest the probe will now get is 15 million miles, in November 1963. Payload was released into orbit by a signal transmitted from the 250 ft. radio telescope at Jodrell Bank, Manchester. Instrumentation on the 5-watt transmitter continued responding to commands from Earth until the probe was 8 million miles distant, when the 150-watt transmitter was switched on.

Unfortunately, this could only be used for a few days following an excessive power drain and an apparent deterioration in the chemical batteries carried. Communication continued, using the 5-watt transmitter and the Jodrell Bank telescope, up to a maximum of 22.5 million miles.

LAUNCHING VEHICLES



U.S. VEHICLES

Jupiter C

Used to launch Explorers 1, 3 *and* 4.

1st stage: Modified Redstone (increased tankage and special Hydyne exotic fuel).
Thrust: 83,000 lb. for 150 seconds.

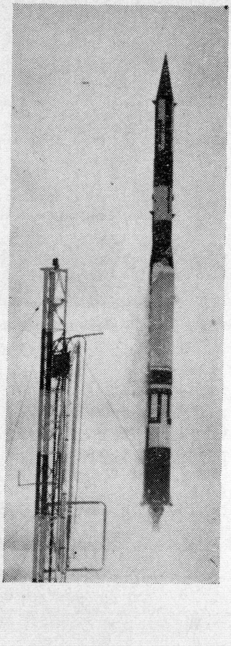
2nd stage: Cluster of 11 scaled-down Sergeants.
Firing time 6 seconds.

3rd stage: Cluster of 3 scaled-down Sergeants.
Firing time 6 seconds.

4th stage: 1 scaled-down Sergeant.
Firing time 6 seconds.

Overall length: 68 ft. 6 in.

Lift-off weight: 65,000 lb.



U.S. Navy TV-3

Used to launch Vanguard Series (*Vanguards* 1, 2 *and* 3).

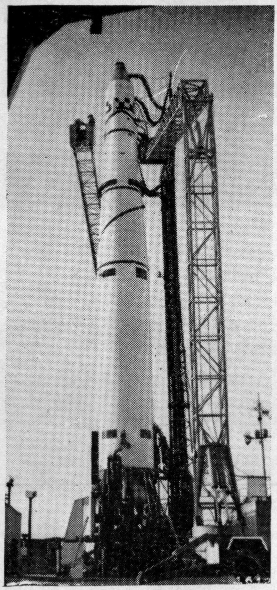
1st stage: Improved Viking (increased tankage).
Propellents: Liquid oxygen: 4% ethyl alcohol and 95% gasoline, 1% lubricating oil.
Thrust: 28,000 lb. for 142 seconds.

2nd stage: Aerojet rocket.
Propellents: Nitric acid; dimethyl-hydrazine.
Thrust: 7,500 lb.

3rd stage: Solid propellent rocket.
Thrust: 2,300 lb.

Overall length: 72 ft. **Lift-off weight:** 22,600 lb.

NOTE: Vehicle used to launch Vanguard 3 *had improved third stage, developing* 3,000 *lb. thrust and burning* 10 *seconds longer.*



Thor-Agena

Used to launch Discoverer series.

1st stage: Modified Thor IRBM.
Propellents: Liquid oxygen and RP-1.
Thrust: 160,000 lb.

2nd stage: Lockheed Agena.
Propellents: Liquid.
Thrust: 15,000 lb.

Overall length: 78 ft. 2½ in. (approx.).

Lift-off weight: 108,500 lb. (approx.).

NOTE: Slight variations in length and thrust were made during development of the Discoverer programme. Vehicles for early Discoverers were known as Thor-Hustlers pending the naming of the second stage, powered by Bell Hustler engine.

Atlas 10B (WS-107A-1)

Comprised the SCORE satellite.

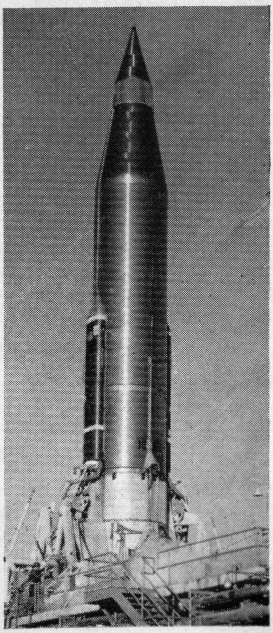
1st stage: Twin side-mounted boosters.
Propellents: Liquid oxygen and RP-1.
Thrust: 2×150,000 lb. for 60 seconds (approx.).

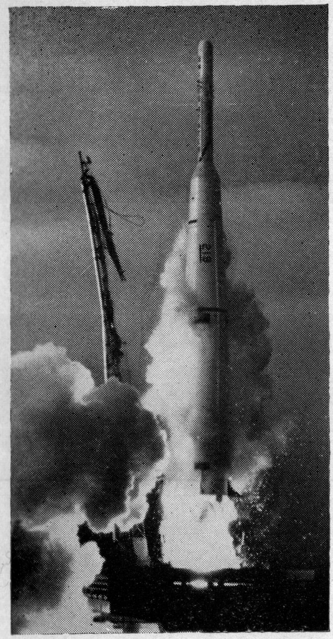
2nd stage: Main body of Atlas ICBM.
Propellents: Liquid oxygen and RP-1.
Thrust: 60,000 lb. for 270 seconds. (Thrust rose to 80,000 lb. above the atmosphere.)

Overall length: 85 ft.

Lift-off weight: 244,000 lb. (approx.).

NOTE: Atlas is often described as a 1½-stage missile, as all three motors fire together for take-off. As the side boosters are jettisoned before the sustainer engine burns out, it is treated in this book as a 2-stage rocket.





Thor-Able

Used to launch Pioneers 1 *and* 5, *Explorer* 6, *and Tiros* 1.

1st stage: Modified Thor IRBM.
Propellents: Liquid oxygen and RP-1.
Thrust: 165,000 lb. for 160 seconds.

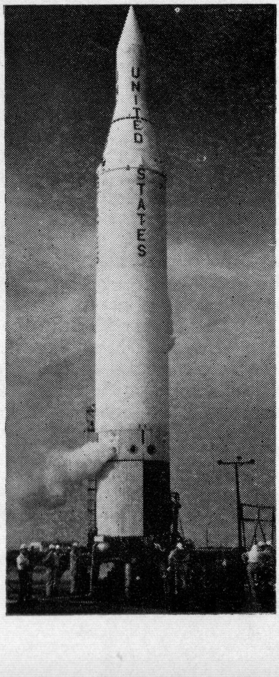
2nd stage: Modified Vanguard second stage.
Propellents: IFNA and UDMH.
Thrust: 7,500 lb. for 100 seconds.

3rd stage: Vanguard third stage (ABL.X2).
Propellents: Solid.
Thrust: 3,000 lb. for 40 seconds.

Overall length: 90 ft.

Lift-off weight: 105,000 lb.

NOTE. Figures apply to the improved Able 4 *vehicle used to launch Pioneer* 5. *The Pioneer* 1 *vehicle included a small solid-propellent retro-rocket, sometimes considered a fourth stage.*



Juno 2

Used to launch Pioneers 3 *and* 4, *and Explorer* 7.

1st stage: Modified Jupiter IRBM.
Propellents: Liquid oxygen and RP-1.
Thrust: 150,000 lb. for 180 seconds.

2nd stage: 11 scaled-down Sergeants.

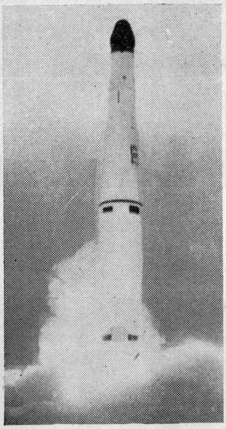
3rd stage: 3 scaled-down Sergeants.

4th stage: 1 scaled-down Sergeant.

Overall length: 76 ft.

Lift-off weight: 121,000 lb.

Guidance: Delta Minimum Inertial Guidance Scheme; pre-controlled before launch.



Thor-AbleStar

Used to launch Transit 1-B, 2-A, N.R.L., & Courier 1-B.

1st stage: Modified Thor IRBM.
Propellents: Liquid oxygen and RP-1.
Thrust: 150,000 lb. for 160 seconds.

2nd stage: AbleStar.
Propellents: IFNA and UDMH.
Thrust: 7,890 lb. for 300 seconds.

Overall length: 79ft. 3½in. **Lift-off weight:** 105,000 lb.

Atlas-Agena

Used to launch Midas 2.

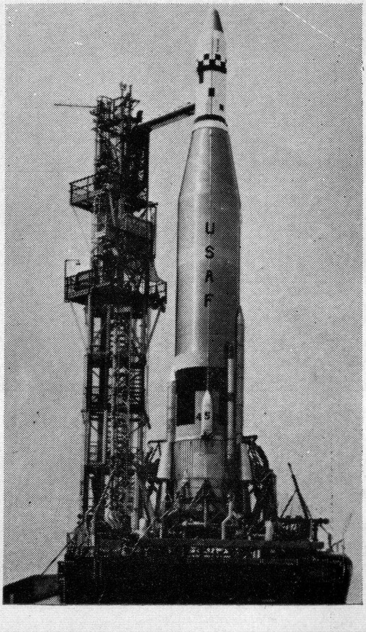
1st stage: Twin, side-mounted boosters of modified Atlas ICBM.
Propellents: Liquid oxygen and RP-1.
Thrust: Two 150,000 lb. for 60 seconds (approx.).

2nd stage: Modified Atlas ICBM.
Propellents: Liquid oxygen and RP-1.
Thrust: 60,000 lb. for 4½ minutes (approx.).

3rd stage: Agena A.
Propellents: IFNA and JP-4.
Thrust: 15,000 lb.

Overall length: 99 ft.

Lift-off weight: 260,000 lb.



Remarks:

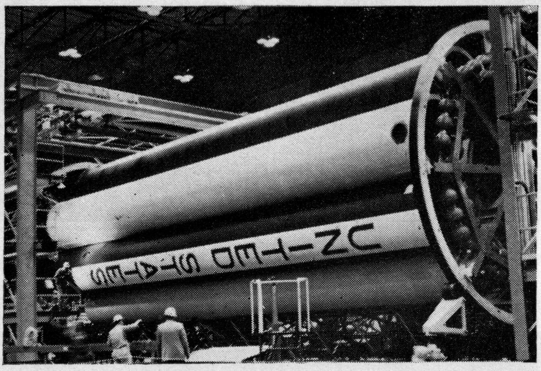
This vehicle promises to become the West's premier space booster; 104 are planned to be launched during the next ten years. The Agena second stage, developed by Lockheed, is the most capable currently available.

The Agena B is an improved vehicle; one of the main advantages will be that the Bell Hustler engine can be restarted in space.

This vehicle is scheduled to place 5,000 lb. payloads in 300-mile orbit, hard-land 800 lb. on the Moon, soft-land 200 lb. on the Moon, or deliver 1,000 lb. to the vicinity of the planets. Lift-off weight of the developed vehicle will be 280,000 lb.

Later plans include the Centaur second stage with twin 20,000 lb. thrust liquid hydrogen engines. This will be capable of orbiting 9,000 lb., soft-landing 730 lb. on the Moon, or sending large instrumented payloads deep into space.

Saturn



Large booster under development. First stage comprises a cluster of eight up-rated Thor-type Rocketdyne H-1 engines, developing a total thrust of 1,500,000 lb.

Second stage will be powered by a cluster of four Centaur-class engines, developing a total thrust of 80,000 lb. The third stage will be a modified Centaur stage driven by two of these engines.

When fully developed, Saturn should be able to boost a 25,000 lb. payload into a 300-mile orbit.

Scout

4-stage solid-propellent vehicle under development for use by countries in association with the U.S.A.

1st stage: Aerojet-General Algol; modified version of early Polaris engine.

2nd stage: Castor (Improved Thiokol Sergeant).

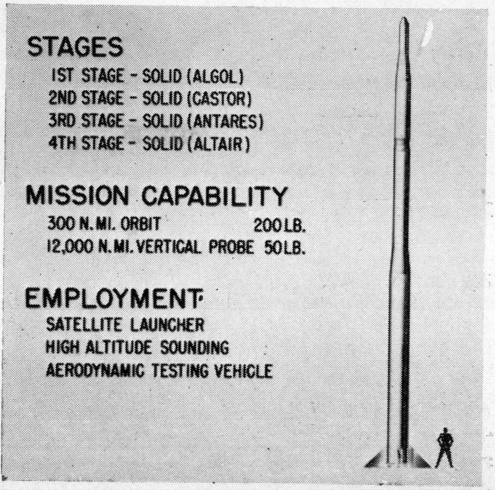
3rd stage: Antares (Scaled-up Vanguard third stage (ABL- X-254)).

4th stage: Altair (Improved Vanguard third stage (ABL-X-248)).

Overall length: 72 ft.

Lift-off weight: 36,100 lb.

Gyro-control system and spin-stabilisation devices by Minneapolis-Honeywell Regulator Co.



STAGES

1ST STAGE - SOLID (ALGOL)

2ND STAGE - SOLID (CASTOR)

3RD STAGE - SOLID (ANTARES)

4TH STAGE - SOLID (ALTAIR)

MISSION CAPABILITY

300 N. MI. ORBIT 200 LB.

12,000 N. MI. VERTICAL PROBE 50 LB.

EMPLOYMENT

SATELLITE LAUNCHER

HIGH ALTITUDE SOUNDING

AERODYNAMIC TESTING VEHICLE

Two faces of the bronze medal struck to commemorate the flight of **Lunik 2.**

U.S.S.R. VEHICLES

No photographs have been released of any Russian satellite or Moon probe launching vehicles, and only extremely meagre details have filtered through from semi-official sources, the authenticity of which is doubtful.

It is generally assumed that the Russian satellites have been launched by modified military weapons. These, designed to lift a heavier nuclear warhead than the miniaturised payload of the U.S. IRBMs and ICBMs, have given the U.S.S.R. a considerable advantage in satellite booster capacity over the U.S.A.

Sputnik 1 Vehicle

Data broadcast over Moscow radio shortly after the launching of Sputnik 1 indicated that this was a three-stage vehicle, powered by a first stage motor of 264,000 *lb. thrust.*

Second stage: 79,000 lb. thrust. **Third Stage:** *no data.*

Sputnik 2 Vehicle

2nd stage: 75 ft. long (estimated).

Sputnik 3 Vehicle

No data available.

Lunik 1 Vehicle

Final stage: 20 ft. long by 10 ft. diameter.

The Journal of the Hungarian Academy of Sciences contained the following unauthenticated data:

4-stage vehicle. **Lift-off weight:** 400 tons. **First stage:** 300 tons. **Second stage:** 75 tons. **Third stage:** 16 tons. **Fourth stage:** 9 tons. **Burning time:** 4 minutes.

GLOSSARY OF SPACE TERMS

Aphelion: Point farthest from the Sun in an elliptical orbit around the Sun.

Apogee: Point farthest from the Earth in an elliptical orbit around the Earth.

Astrophysics: Study of the physical and chemical nature of celestial bodies and their environs.

Ballistic Trajectory: Path of ballistic vehicle in unpowered portion of flight.

Bi-propellent: A rocket propellent consisting of two unmixed or uncombined chemicals (fuel and oxidant) fed separately to the combustion chamber.

Booster: Propulsion unit used in initial stage of flight.

Burnout: Point of rocket engine shutdown.

Centrifugal Force: Apparent force tending to carry an object away from a centre of rotation.

Circular Velocity: Speed required to maintain a body in a circular orbit.

Doppler Effect: Apparent change in frequency of sound or light due to motion.

Eccentricity: Degree of deviation from a circular orbit.

Escape Velocity: Minimum speed required to overcome (but not entirely escape from) the effect of gravity.

Exhaust Velocity: Speed at which the jet gases are expelled from the nozzle.

Free Fall: The motion of any unpowered body travelling in a gravitational field.

IFNA: Inhibited red fuming nitric acid (oxidant).

Mass Ratio: Ratio of a rocket's mass at launch to its mass at burnout (*e.g.*, if it weighs 100 lb. at launch and 10 lb. at burnout, the ratio is 10:1).

Monopropellent: A rocket propellent consisting of a single substance, especially a liquid containing both fuel and oxidant, combined or mixed.

Orbit: Path of a body relative to its primary.

Orbital Velocity: Speed of a body following a closed or open orbit, most commonly applied to elliptical or near-circular orbits.

Perigee: Point which is nearest the Earth in an elliptical orbit around the Earth.

Perihelion: Point which is nearest the Sun in an elliptical orbit around the Sun.

Period: Time required for an orbiting body to make a single revolution around its primary.

Primary: The body around which a satellite orbits.

Probe: Unmanned projectile sent into space purely to gather information.

Propellent: Liquid or solid substance burned in a rocket to develop thrust.

Satellite: Body moving around a primary.

Sounding Rocket: Rocket used for carrying instruments to high altitudes for " sounding " the upper atmosphere.

Specific Impulse: Amount of thrust derived from each pound of propellent in one second of engine operation. Specific impulse to the rocket engineer means much the same as miles-per-gallon to a motorist; it is a measure of the efficiency with which the rocket propellents are being used to generate thrust. With chemical propellents, specific impulses of up to 400 seconds are theoretically possible.

Telemetering: Technique of recording data associated with some distant event, usually by radioing an instrument reading from an aircraft or rocket to a recording machine on the ground.

Thrust: Amount of " push " developed by a rocket; measured in pounds.

Thrust-to-weight ratio: Relation of engine thrust to the vehicle's total weight.

Total Impulse: Product of thrust of rocket engine multiplied by the time of propellent burning.

Trajectory: Path described by missile or space vehicle.

UDMH: Unsymmetrical dimethyl hydrazine (fuel).

Weightlessness: Apparent absence of weight during " free fall " (*which see*).

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